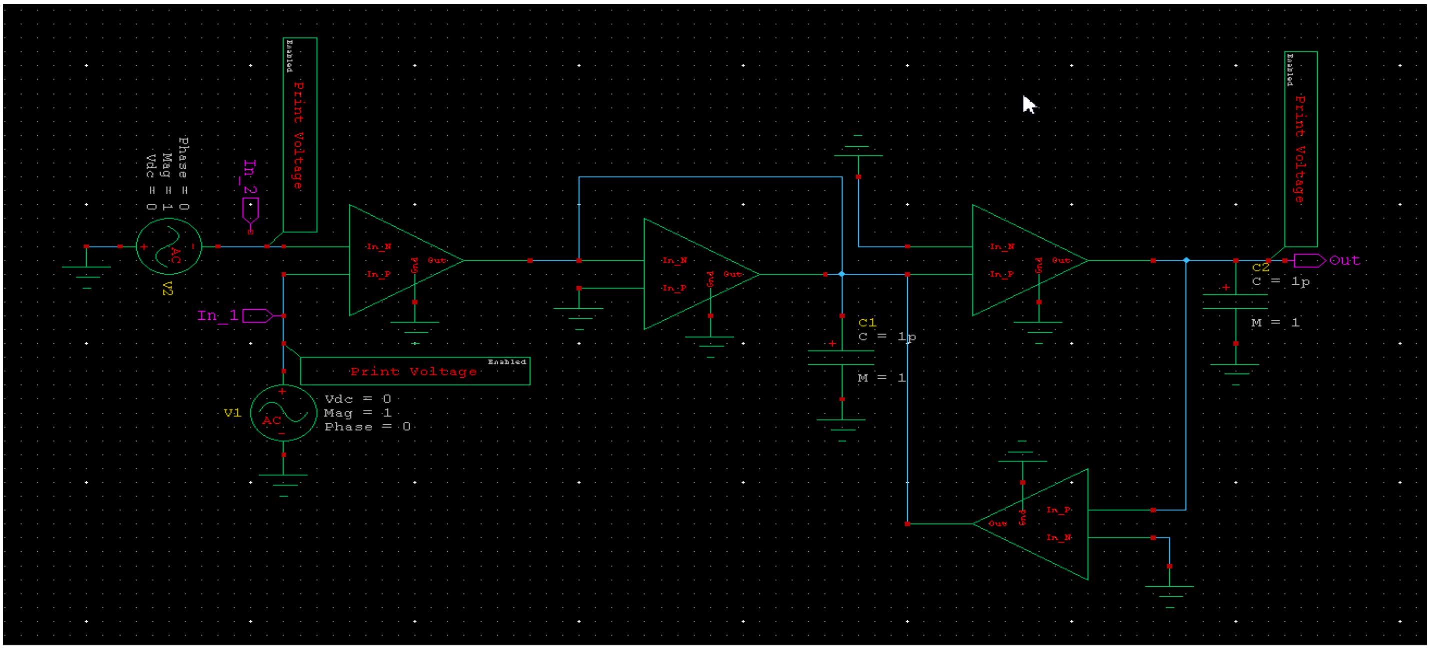
HIGHER ORDER GMC FILTERS(BY CASCADING BIQUAD STAGES)

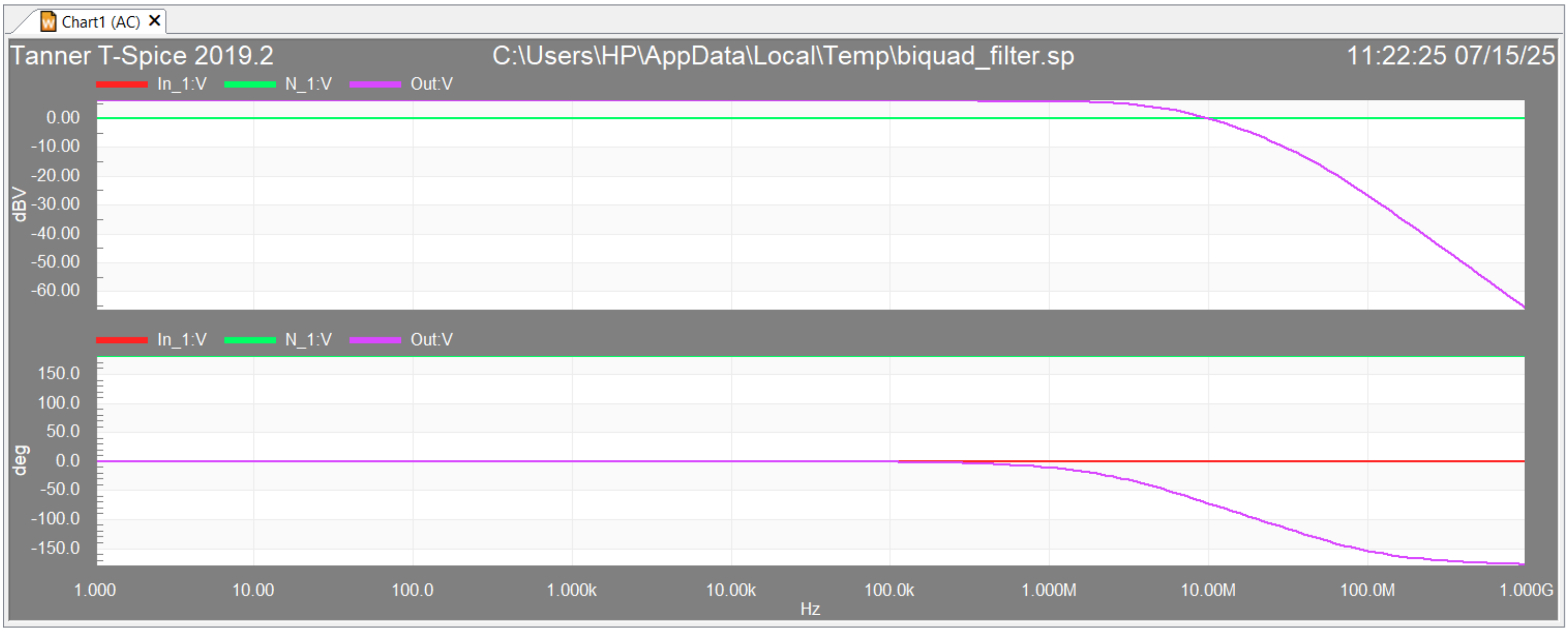
1.BIQUAD FILTER:

A biquad Gm-C filter is a second-order active filter constructed using Operational Transconductance Amplifiers (OTAs) and capacitors. The term "biquad" indicates that the circuit has a quadratic transfer function, making it capable of implementing low-pass, band-pass, or high-pass responses depending on the configuration.In this design, OTAs replace traditional op-amps, allowing tunability through transconductance () instead of resistor values. The biquad topology provides a stable and easily tunable frequency response, making it suitable for integration in CMOS technologies. The frequency characteristics are primarily determined by the values of the capacitors and the transconductance of OTAs.This circuit represents one stage of a higher-order filter when multiple biquads are cascaded.



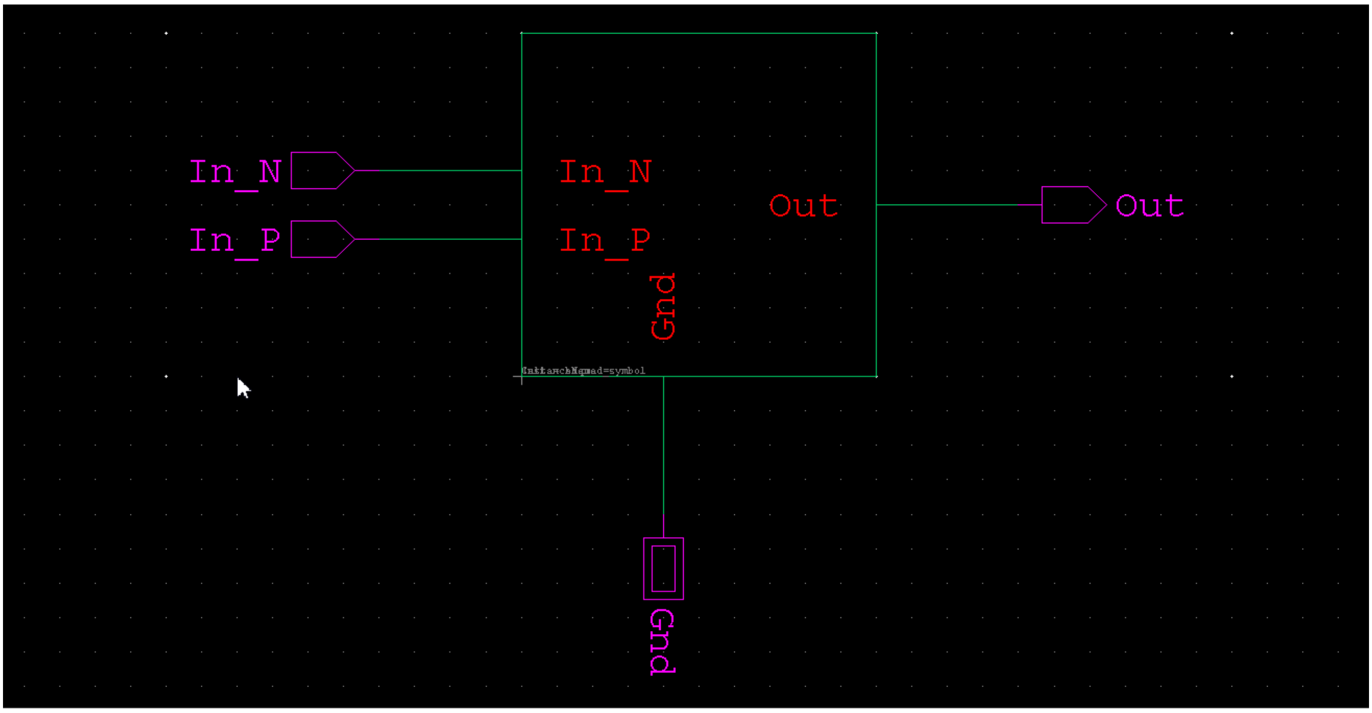
SIMULATION RESULTS:

The magnitude and phase response of the biquad filter are shown below. The frequency response indicates a second-order low-pass characteristic, where the gain drops significantly after the cutoff frequency.



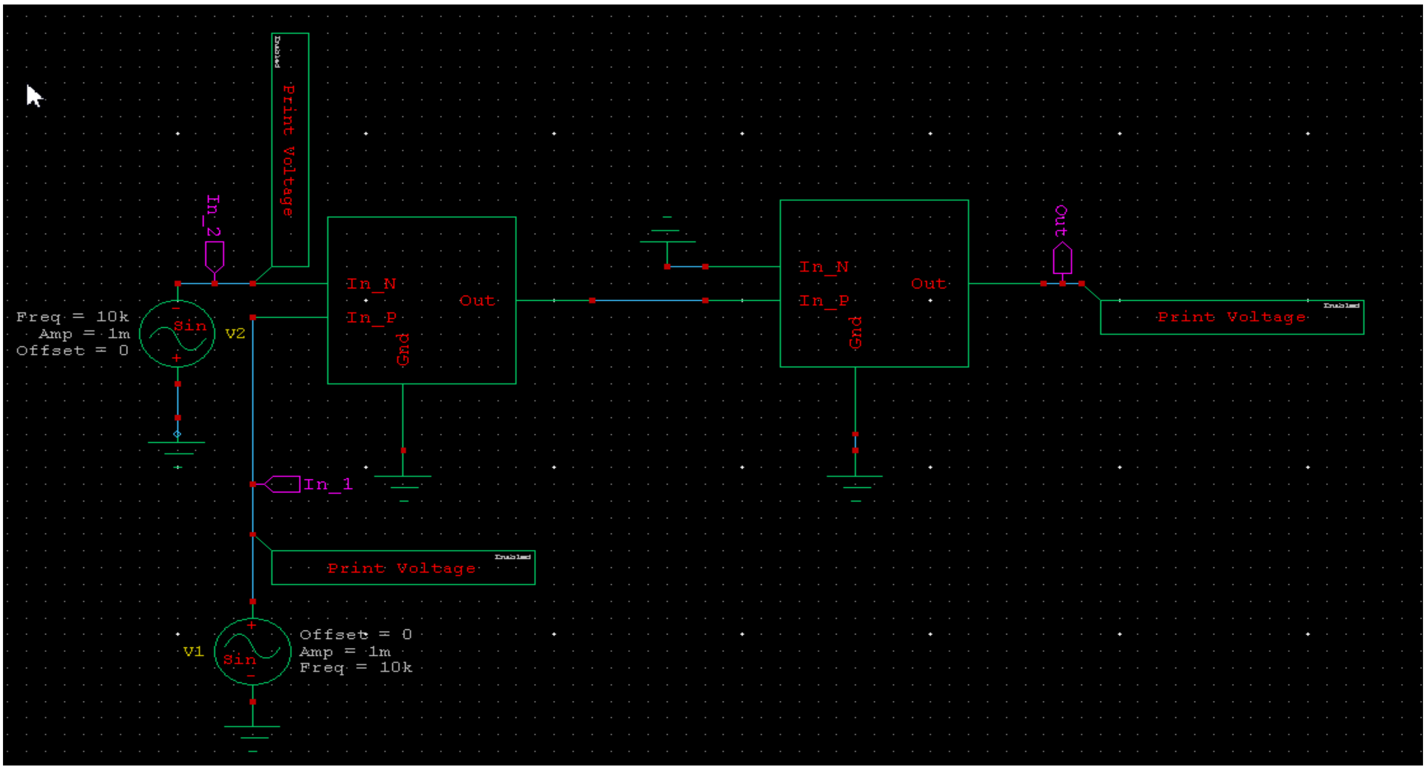
2.Biquad symbol for Cascading

To simplify higher-order filter design, a symbolic representation of the biquad Gm-C stage is used. This abstraction allows for easier cascading of multiple biquad stages to form third-, fourth-, or higher-order filters. Each block represents a second-order section, and their interconnection defines the overall filter order and response.



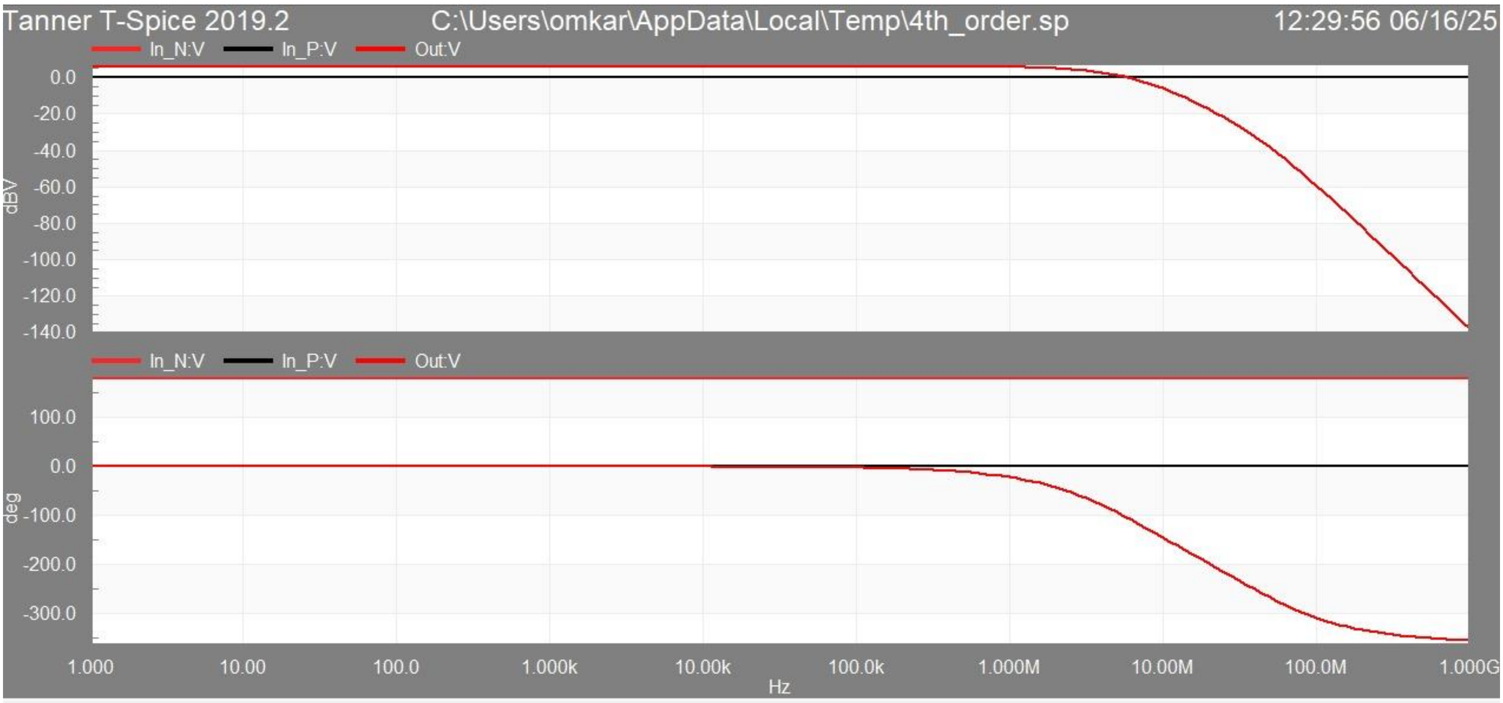
3.4th Order GMC Filter:

A 4th-order Gm-C filter can be implemented by cascading two biquad filter stages. Each biquad stage contributes a second-order response, and their cascade results in a higher selectivity and sharper roll-off. The cutoff frequency and bandwidth are controlled by the transconductance values and the capacitors used in each stage.This modular approach allows easy extension to even higher-order filters and is suitable for integrated analog systems due to OTA-based implementation.



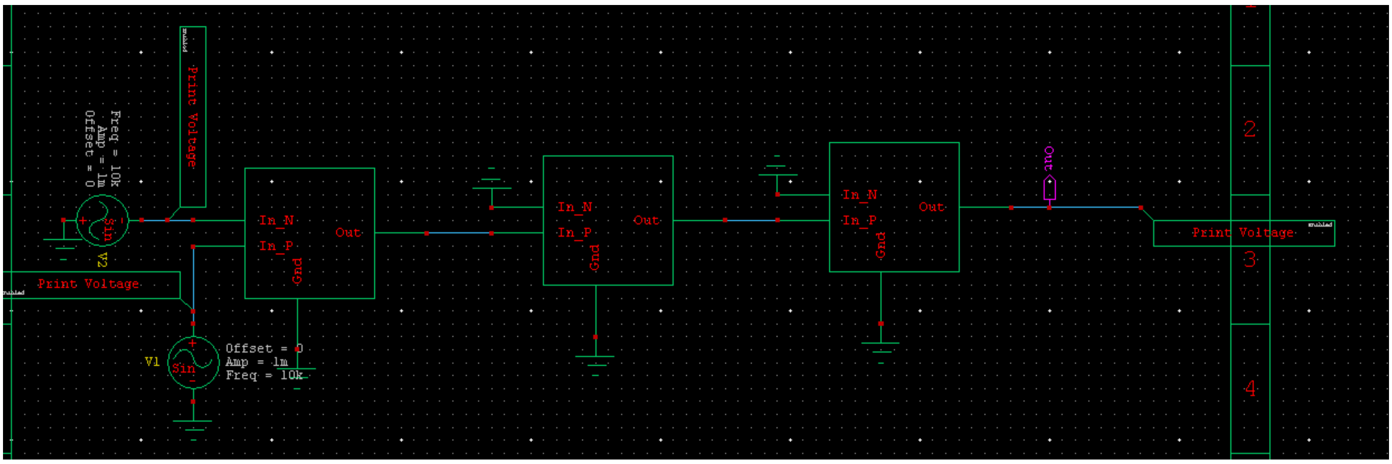
SIMULATION RESULTS:

The magnitude and phase response of the 4^{TH} order gmc filter are shown below. The frequency response of the 4th-order Gm-C filter indicates a sharper roll-off and improved selectivity compared to a single biquad stage. This validates the successful cascading of two second-order stages to achieve the desired higher-order response. The gain drops significantly beyond the cutoff frequency, demonstrating the effectiveness of the filter in attenuating higher frequencies.



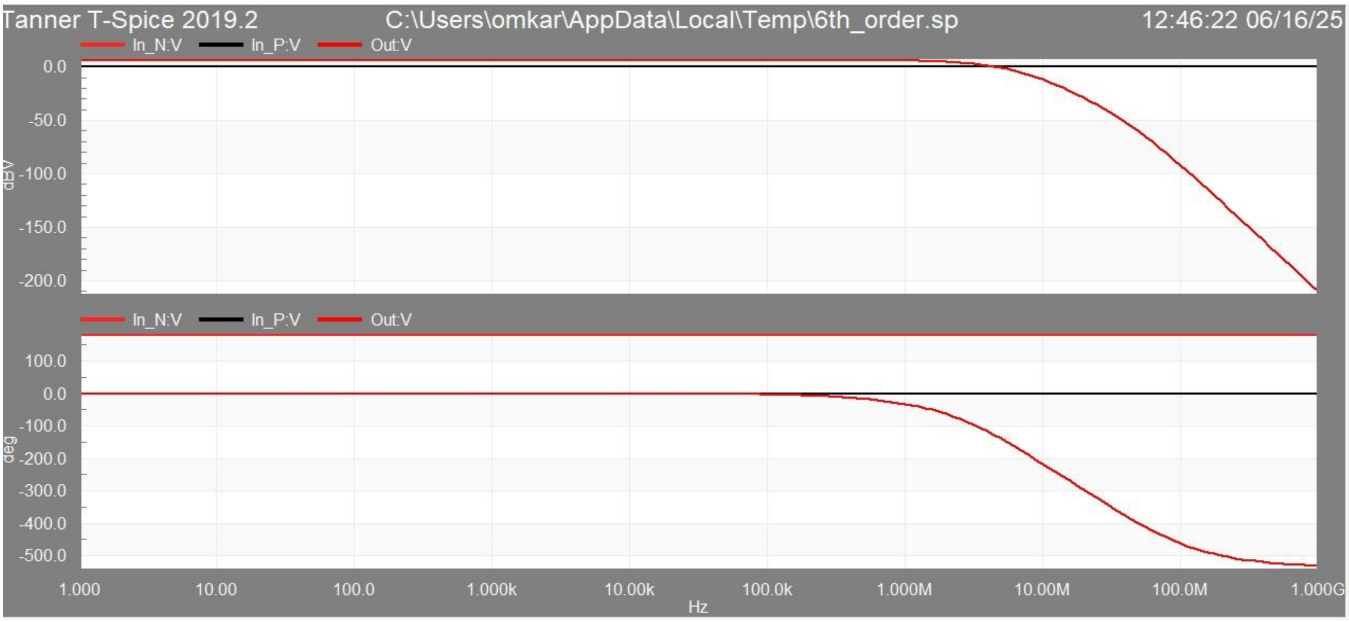
4.6[th] Order GMC Filter:

A 6th-order Gm-C filter is implemented by cascading three second-order biquad stages using Operational Transconductance Amplifiers (OTAs) and capacitors. Each biquad contributes a second-order response, and together they form a filter with a much steeper roll-off and enhanced selectivity compared to lower-order designs. This method offers a modular and scalable approach, making it easier to design filters with precise characteristics such as a desired cutoff frequency and quality factor. By tuning the transconductance values () and capacitors in each stage, the overall frequency response can be adjusted effectively. The OTA-based implementation also makes the design suitable for integration in analog ICs, providing a compact and low-power solution for high-order filtering.



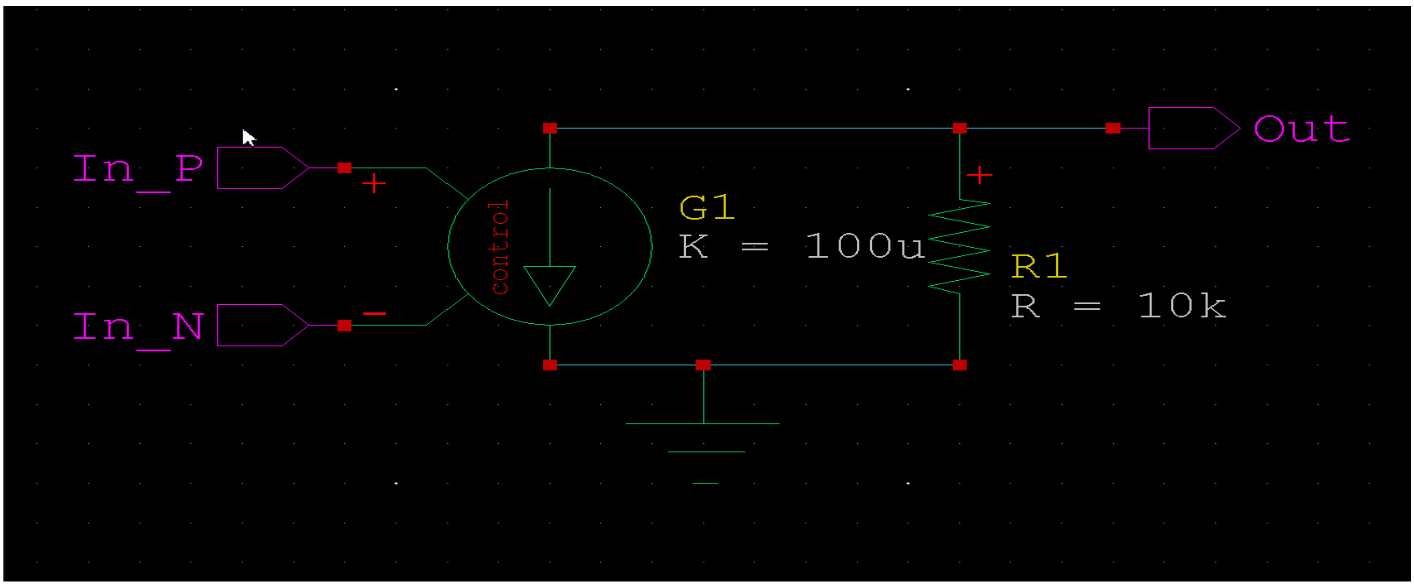
SIMULATION RESULTS:

The simulation shows a sharp gain drop after the cutoff frequency, confirming the expected steep roll-off of a 6th-order low-pass filter. The response clearly demonstrates effective filtering with strong attenuation in the stopband, validating the proper cascading of three biquad stages.



5.Ideal OTA:

All Gm-C filter designs presented in this report are constructed using ideal Operational Transconductance Amplifiers (OTAs) with a constant transconductance value of . This idealized model helps in focusing on filter behavior without considering non-idealities, allowing clear observation of frequency response, cutoff characteristics, and roll-off rates in different filter orders.



6.Results and Summary:

Tanner Spice Software Tool

Biquad GMC (Gm-C) filter

- The filter shows a gain of approximately 6 dB in the passband.
- The cutoff frequency is around 6 MHz.
- The roll-off rate is about 26 dB/decade.
- The unity gain bandwidth (UGB) is 10 MHz.
- Ideal OTAs are used in the construction of this filter.

4th order GMC filter(by cascading two biquad stages)

- The overall filter gain is approximately 6 dB in the passband.
- The cutoff frequency is around 4 MHz.
- The roll-off rate is about 55 dB/decade, providing sharper attenuation than a single biquad.
- The unity gain bandwidth (UGB) is 6 MHz.
- Ideal OTAs are used in the construction of this cascaded filter topology.

6th order GMC filter(by cascading three biquad stages)

- The overall filter gain is approximately 6 dB in the passband.
- The cutoff frequency is around 3 MHz.
- The roll-off rate is about 80 dB/decade, offering steep attenuation beyond the cutoff.
- The unity gain bandwidth (UGB) is 4.5 MHz.
- Ideal OTAs are used in constructing this high-order filter topology.