Two Stage Operational Transconductance Amplifier

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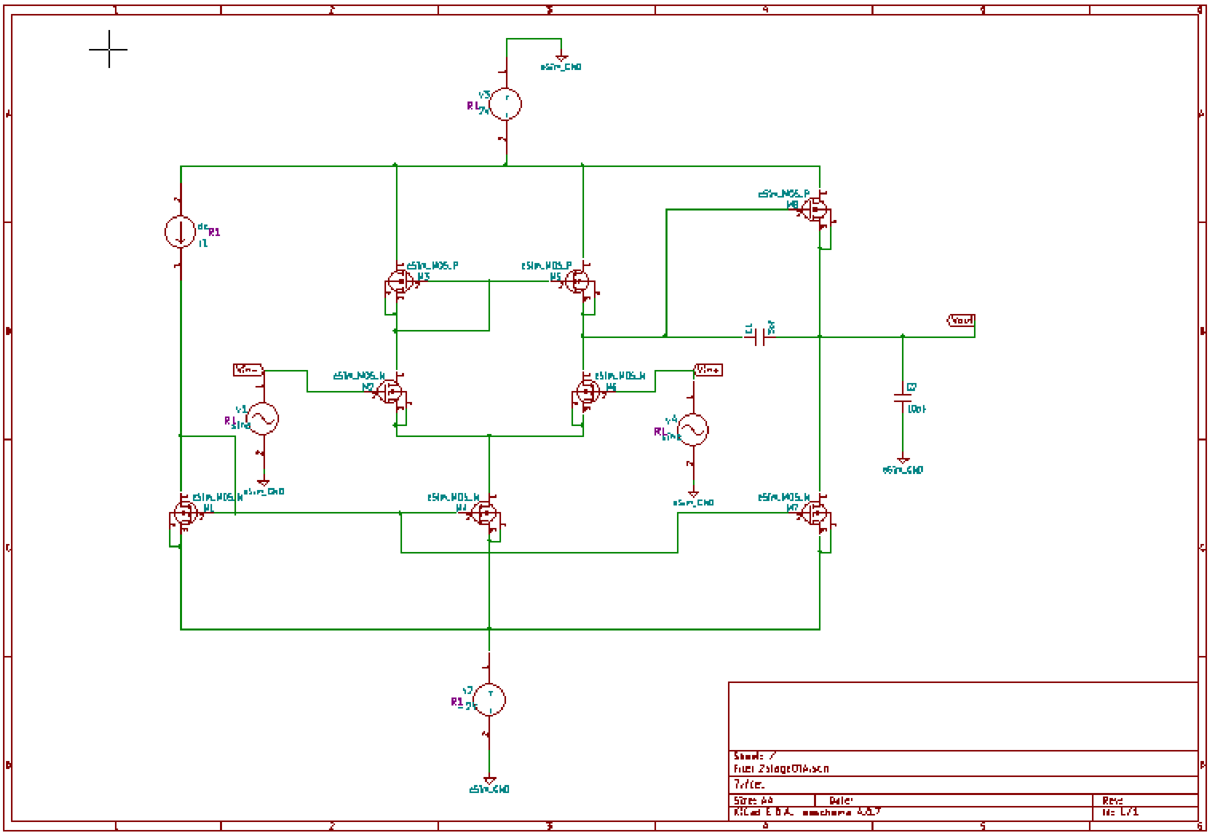
Theory: A **two-stage operational transconductance amplifier (OTA)** is a high-gain analog amplifier widely used in signal processing applications. It consists of two main stages: a differential amplifier (first stage) and a gain stage (second stage). The first stage converts the differential input voltage into a proportional current while offering high input impedance and rejecting common-mode signals, thus providing good initial gain and ensuring high accuracy. The second stage boosts the overall gain and drives the load with a high output swing, making the OTA suitable for various applications.

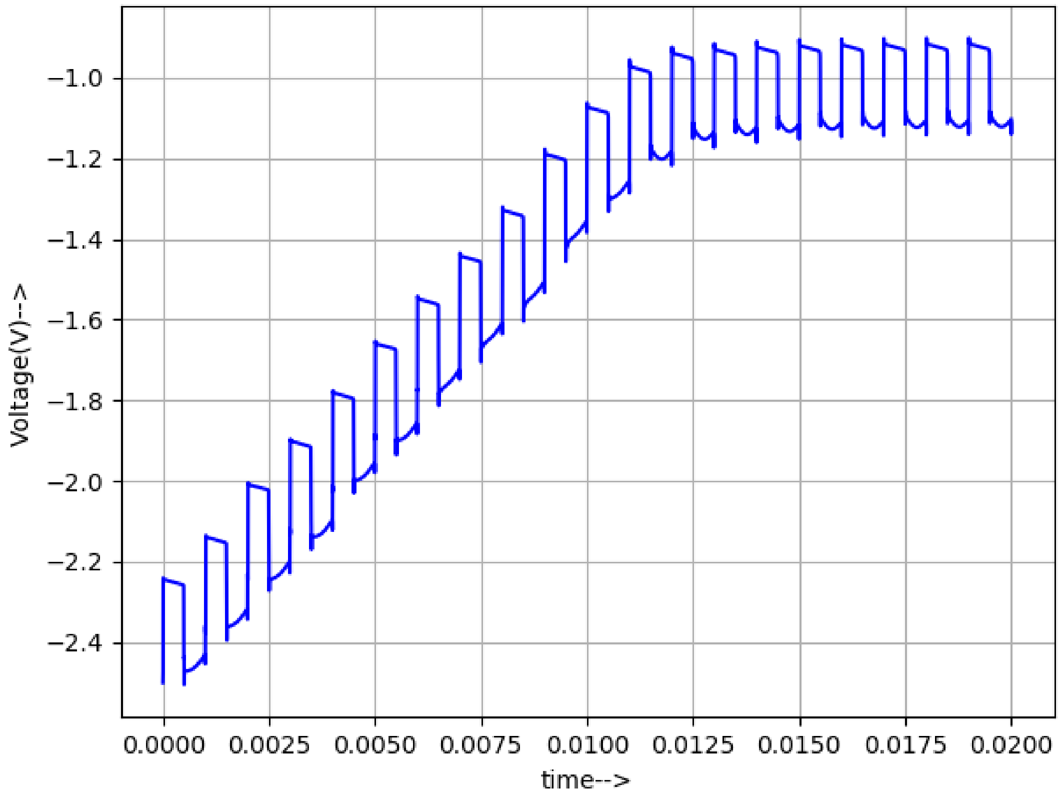
Circuit Diagram



2 stage OTA

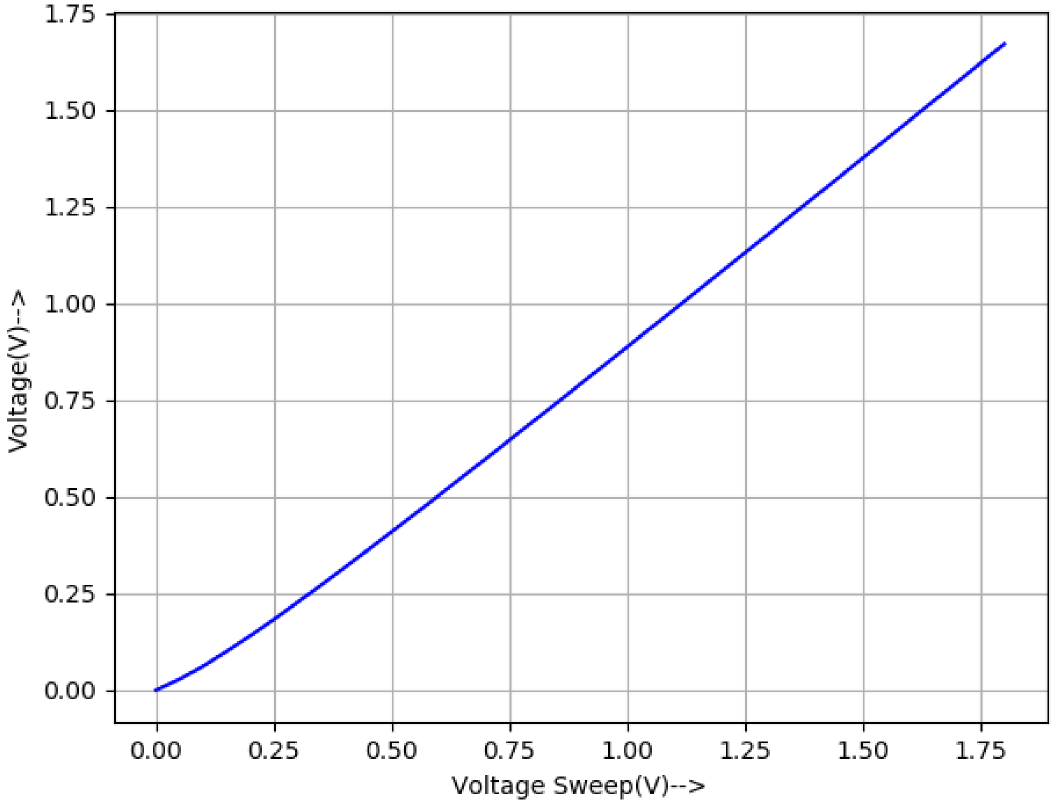
Simulation

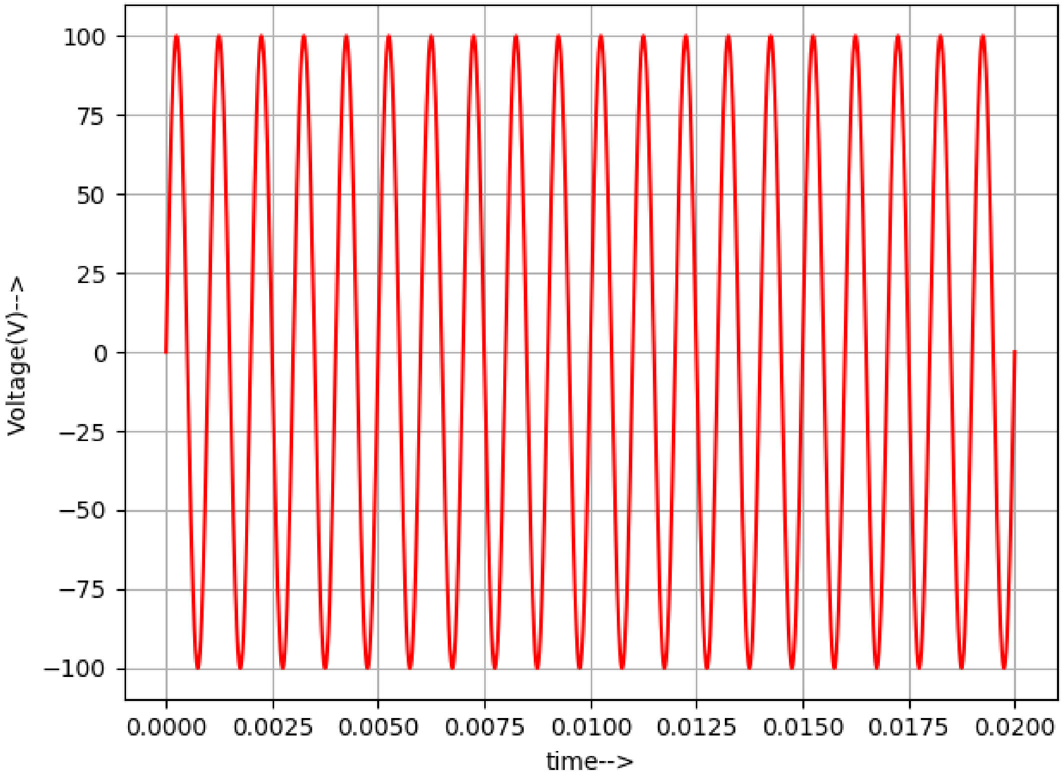
Transient analysis



VOUT

DC Analysis





Vin

Transient Analysis

The transient analysis reveals a **rising voltage pattern** with distinct steps and periodic variations, reflecting the OTA's dynamic signal processing. Each step corresponds to a transient event where the OTA transitions to a new voltage level in response to input changes. The periodic sharp transitions signify the OTA's **slew rate** and its ability to handle rapid input variations, while the smooth rise between steps highlights the combined effect of the **gain stages** and the **compensation network**.

Dc Analysis

The DC transfer characteristic of the two-stage operational transconductance amplifier (OTA) exhibits a linear relationship between the input and output voltages. However, the observed DC gain is approximately 1, which deviates from the expected high gain characteristic of typical two-stage OTAs

Working

The two-stage operational transconductance amplifier (OTA) is a widely used analog circuit that amplifies input signals with high precision and stability. It operates through two main stages to achieve high gain and dynamic performance

The first stage is a differential amplifier, which converts the input differential voltage into a proportional current. This stage provides high input impedance, ensuring minimal loading of the source, and rejects common-mode signals to maintain signal accuracy. It establishes the initial amplification and ensures precise signal processing by suppressing noise and unwanted disturbances.

The second stage is a gain stage, often implemented as a common-source amplifier, which amplifies the current output from the first stage into a large voltage signal. It enhances the overall voltage gain and provides sufficient output swing to meet application requirements while driving the load effectively.

To ensure stability during dynamic operations, a Miller compensation capacitor is used. This capacitor introduces a dominant pole in the frequency response, which suppresses high-frequency oscillations, improves the phase margin, and stabilizes the circuit. This compensation mechanism enables the OTA to handle high-speed transitions in input signals while maintaining accuracy and stability.

References

I. S. Dhanjal, “Two-Stage Operational Transconductance Amplifier,” Lecture Notes, (KJSCE,SVU), (Mumbai, Maharashtra)

Jambek, Asral & Ismail, R.C. & Baharudin, Siti. (2014). Design and Analysis of a Two-Stage OTA for Sensor Interface Circuit. ISCAIE 2014 - 2014 IEEE Symposium on Computer Applications and Industrial Electronics. 10.1109/ISCAIE.2014.7010215.