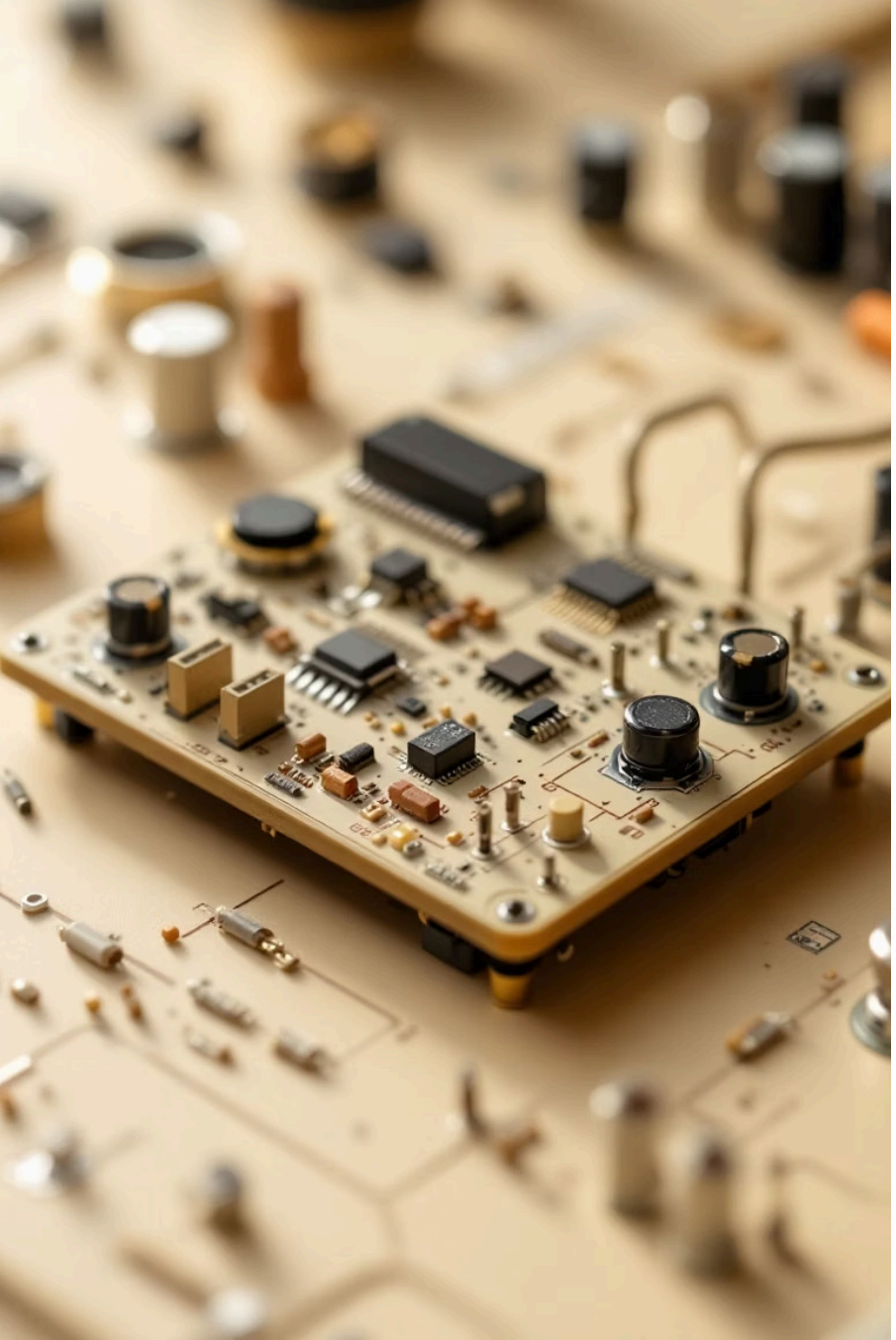


Op-Amp using Discrete Components and its Application

By Manikya Pant and Vedant Pahariya

Design and Simulation

Architecture

Includes differential input, gain stage, and push-pull output.

Transistor Choices

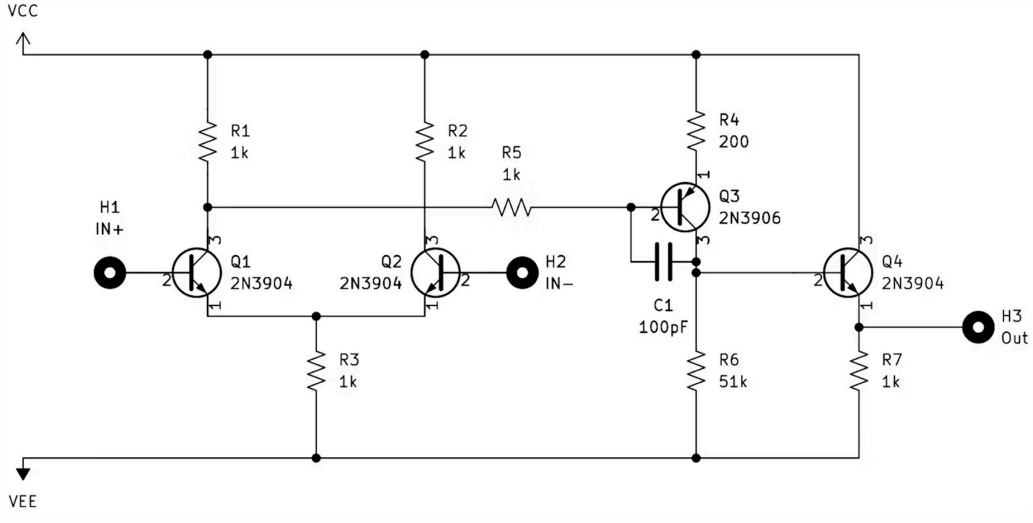
BJT types(BC547B ,2N222N) and (BC557B, 2N3906) for NPN and PNP pairs, and IN4148 diode

Simulation Tools

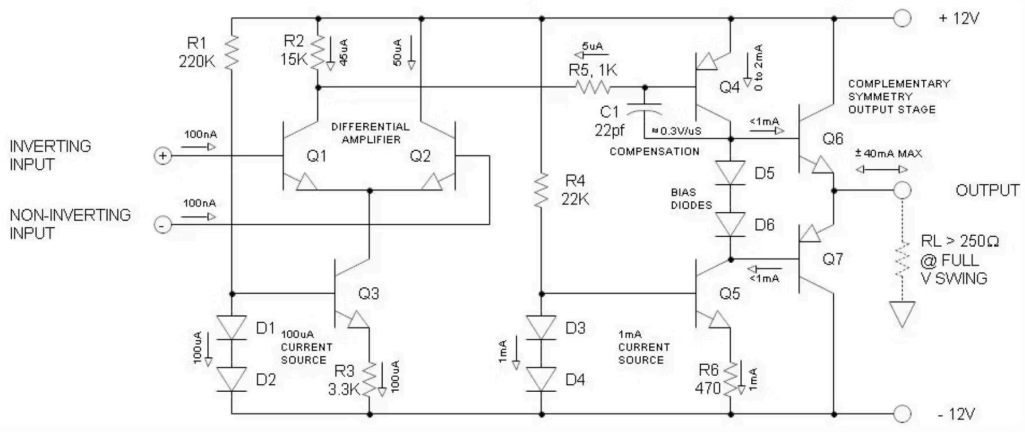
Used LTspice for performance verification.

Different Op Amp Topologies

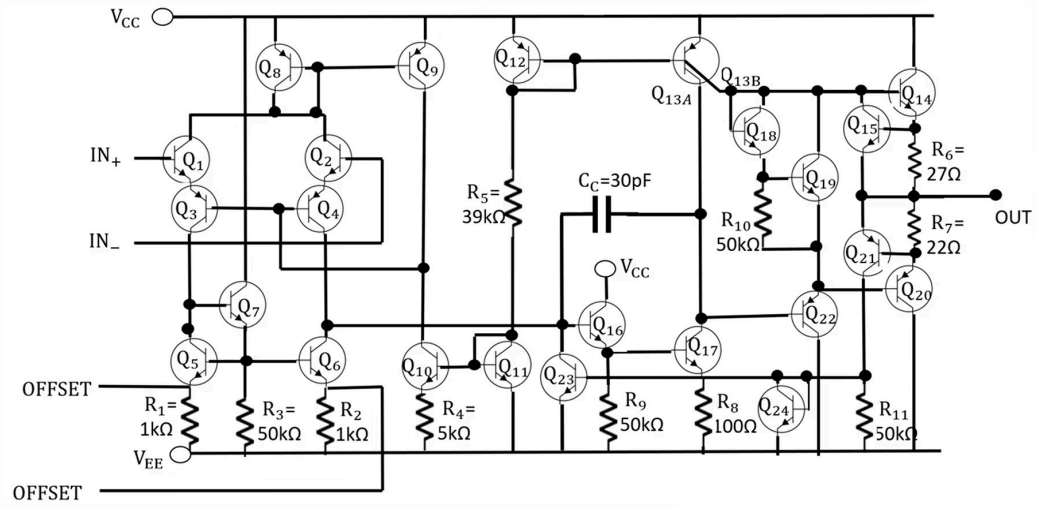
Simplest Op Amp Design



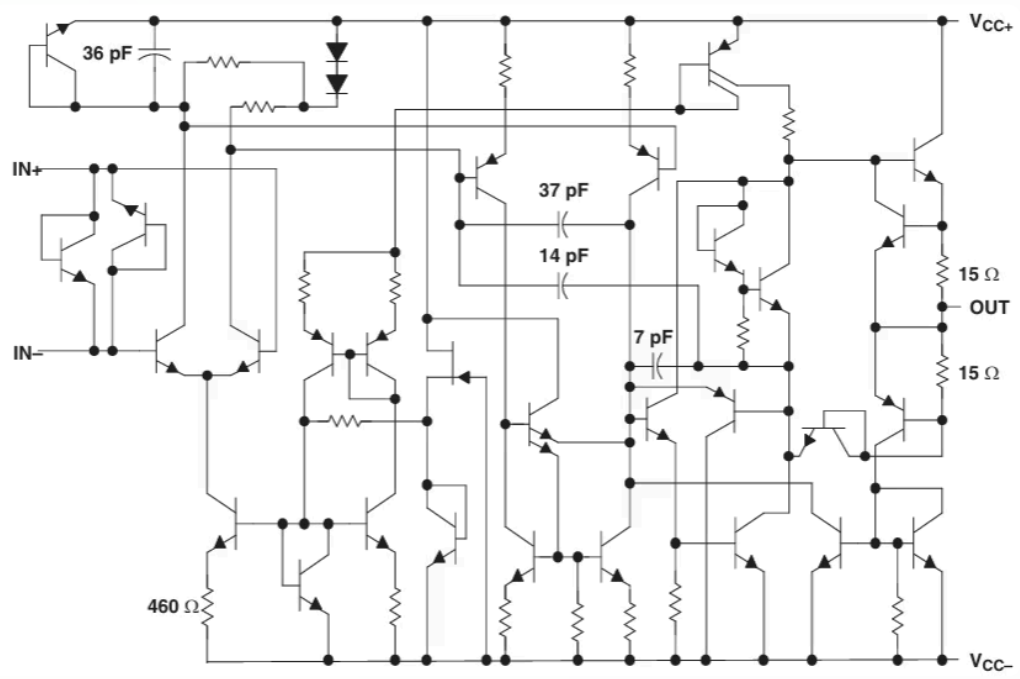
Our Design



UA741

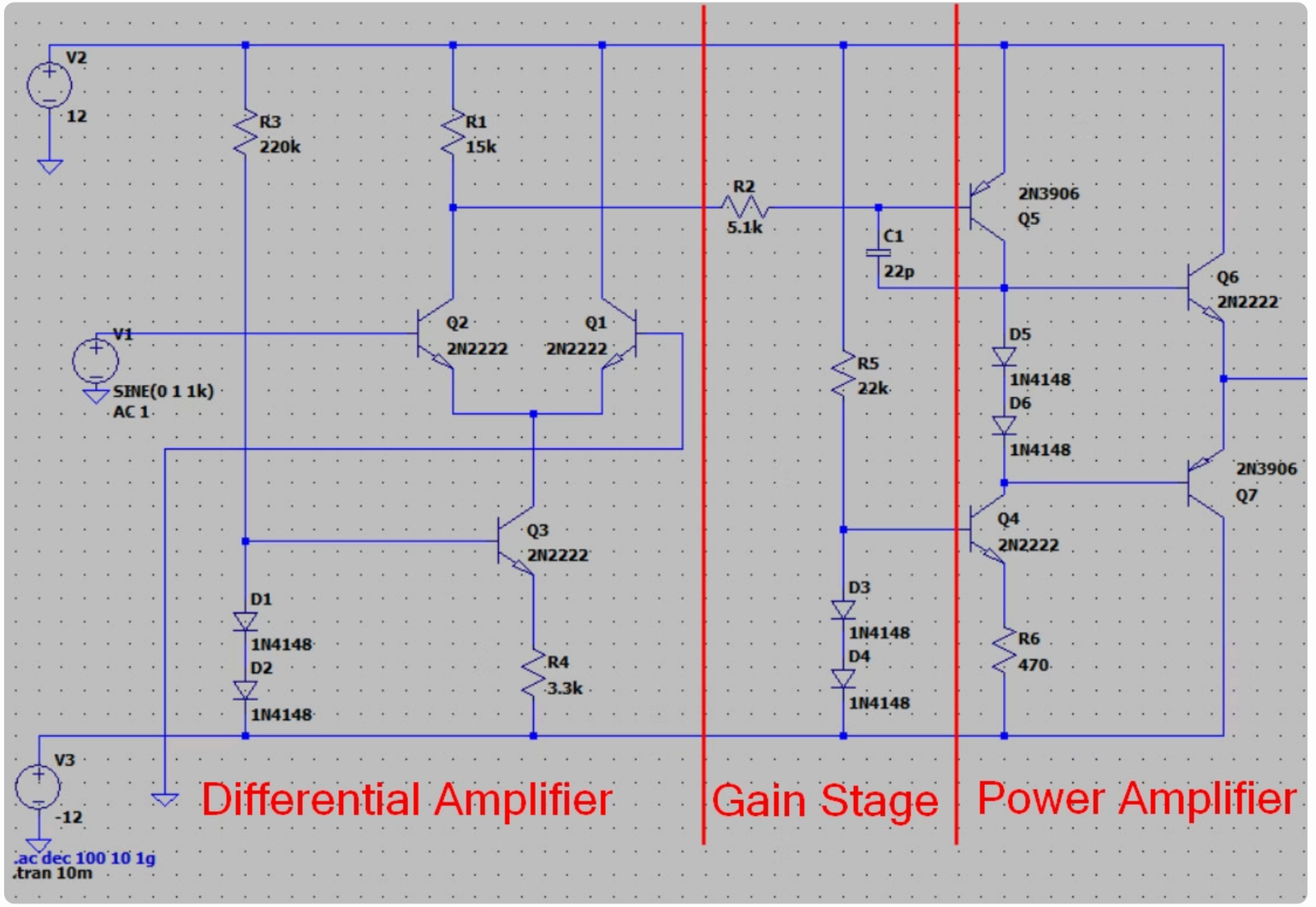


NE5532



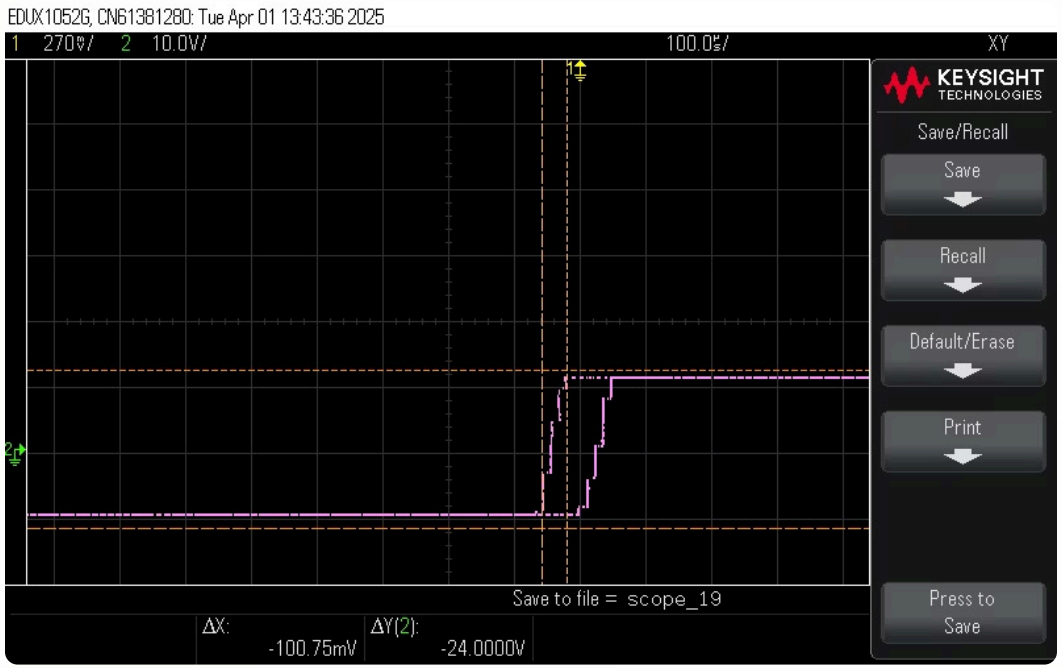
Stages of Op Amp

- Differential Amplifier
- Gain Stage
- Power Amplifier

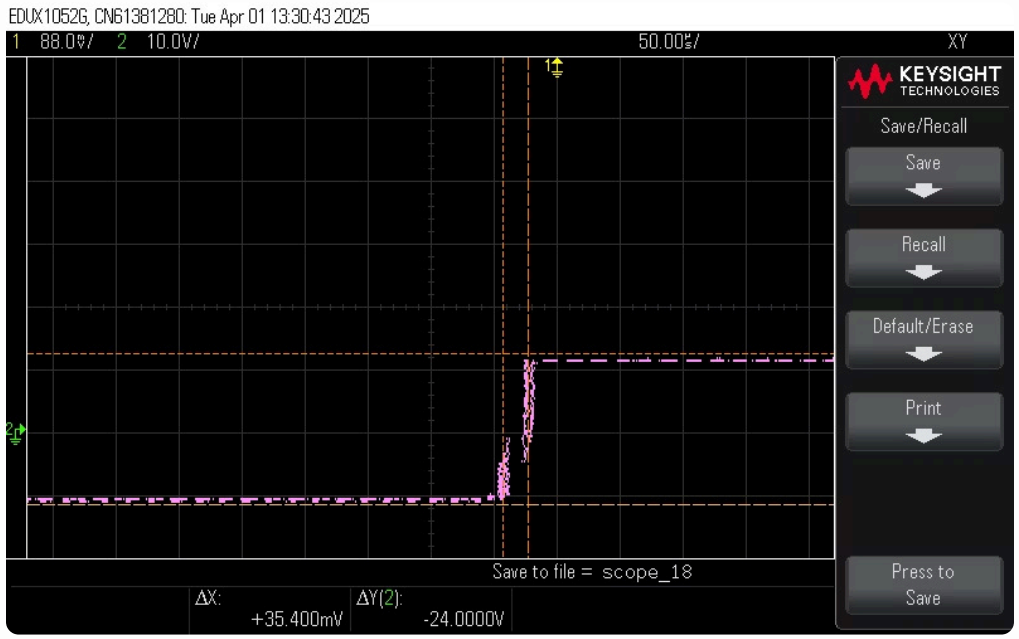


Op Amp Id(differetial input) vs output plot

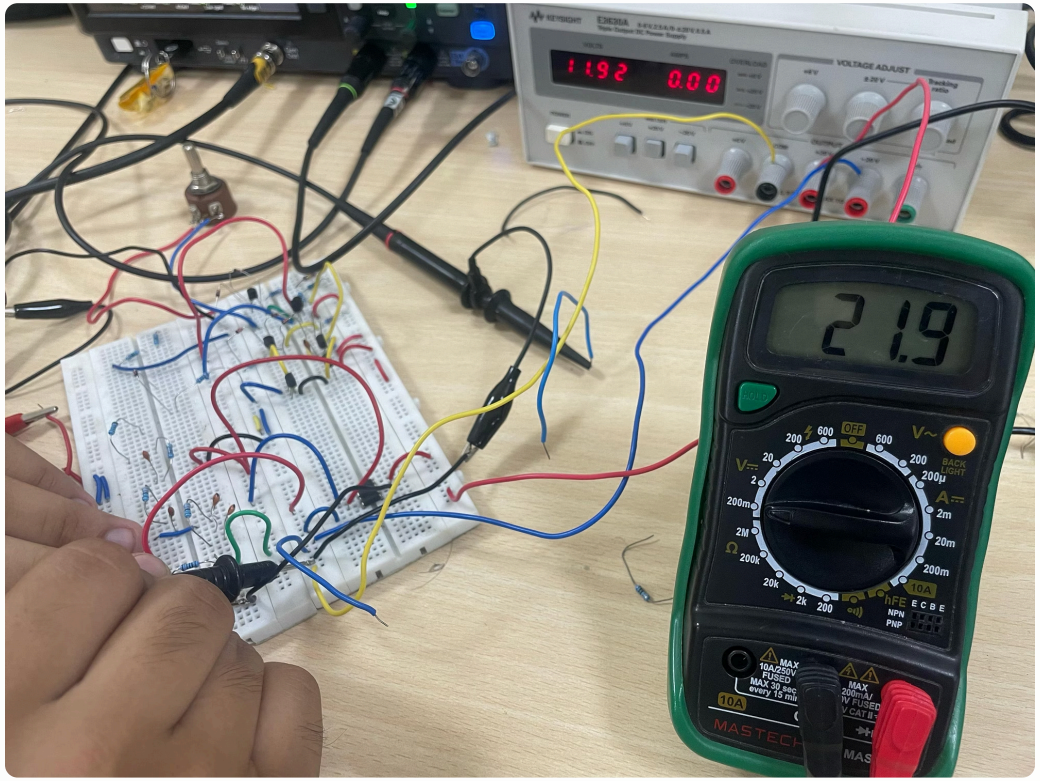
UA741 IC

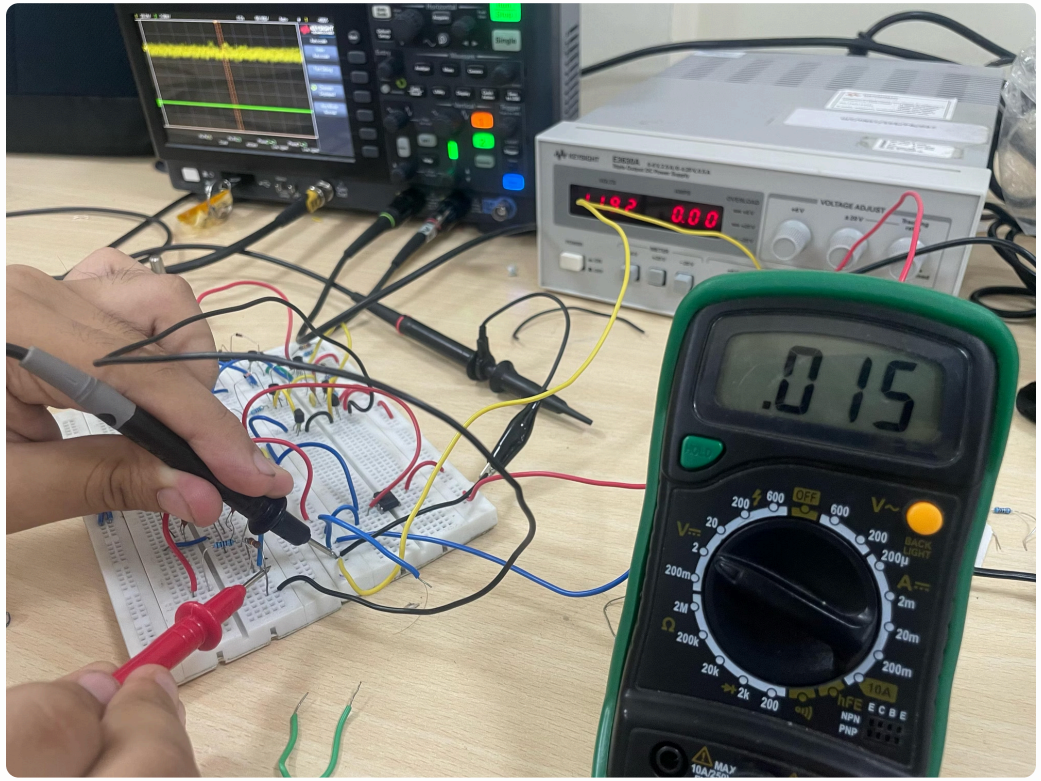


Our op amp



Input Voltage Offset

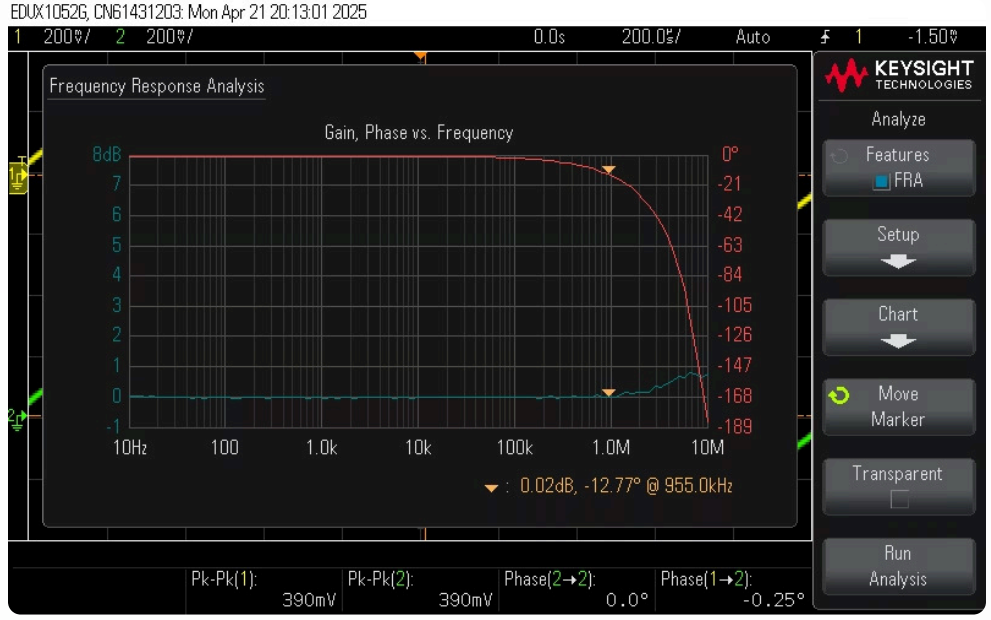




Bandwidth Comparison

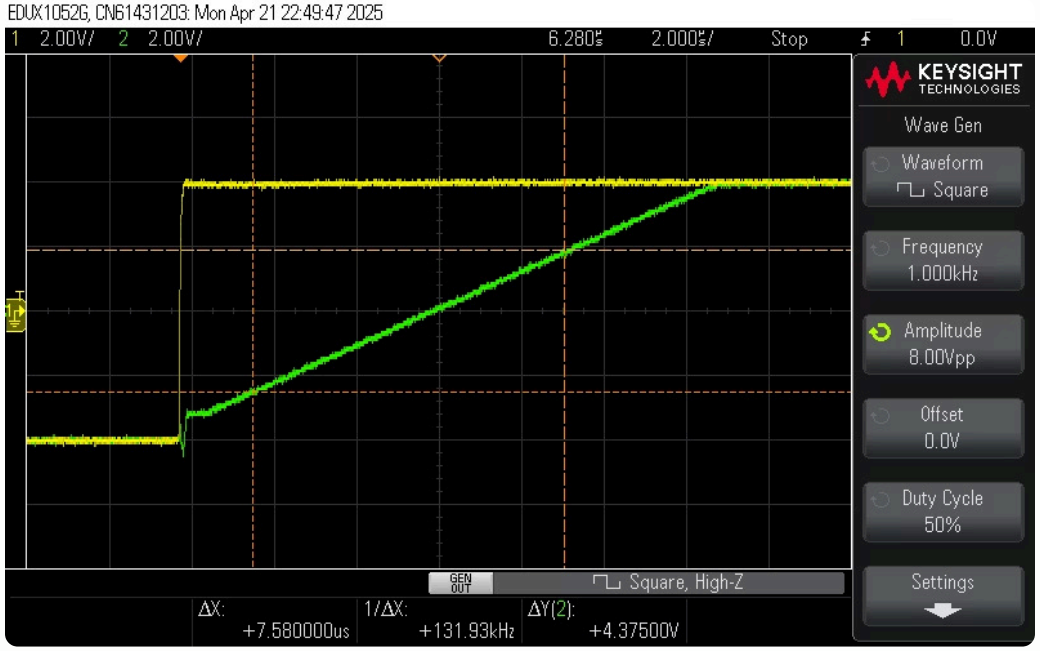
Buffer Configuration of the UA741 Operational Amplifier

Buffer Configuration Used in Our Discrete Op Amp Design

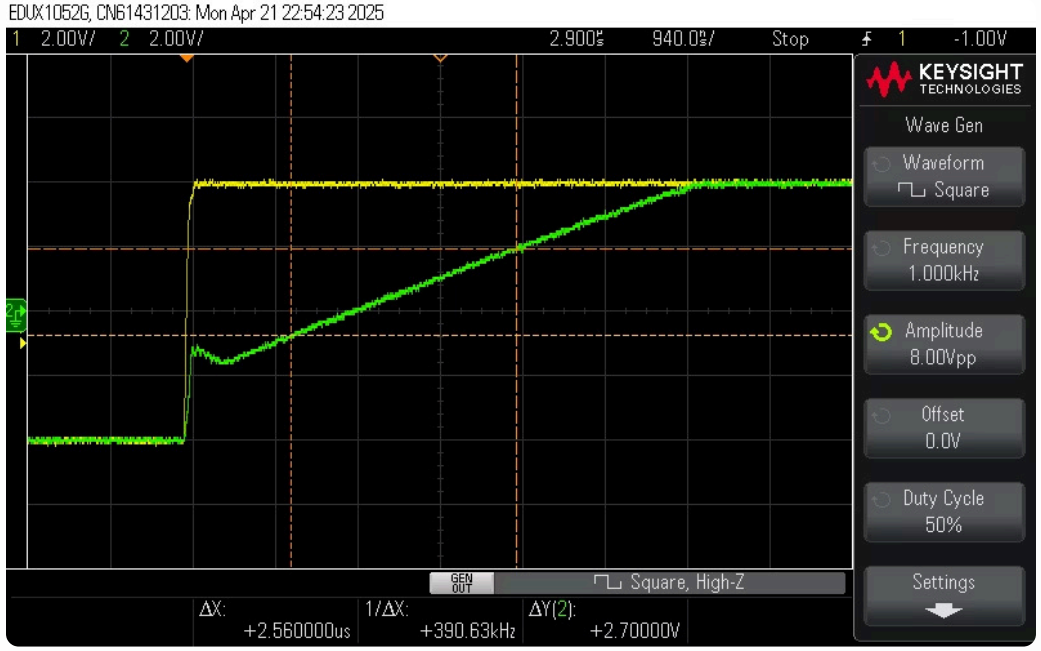


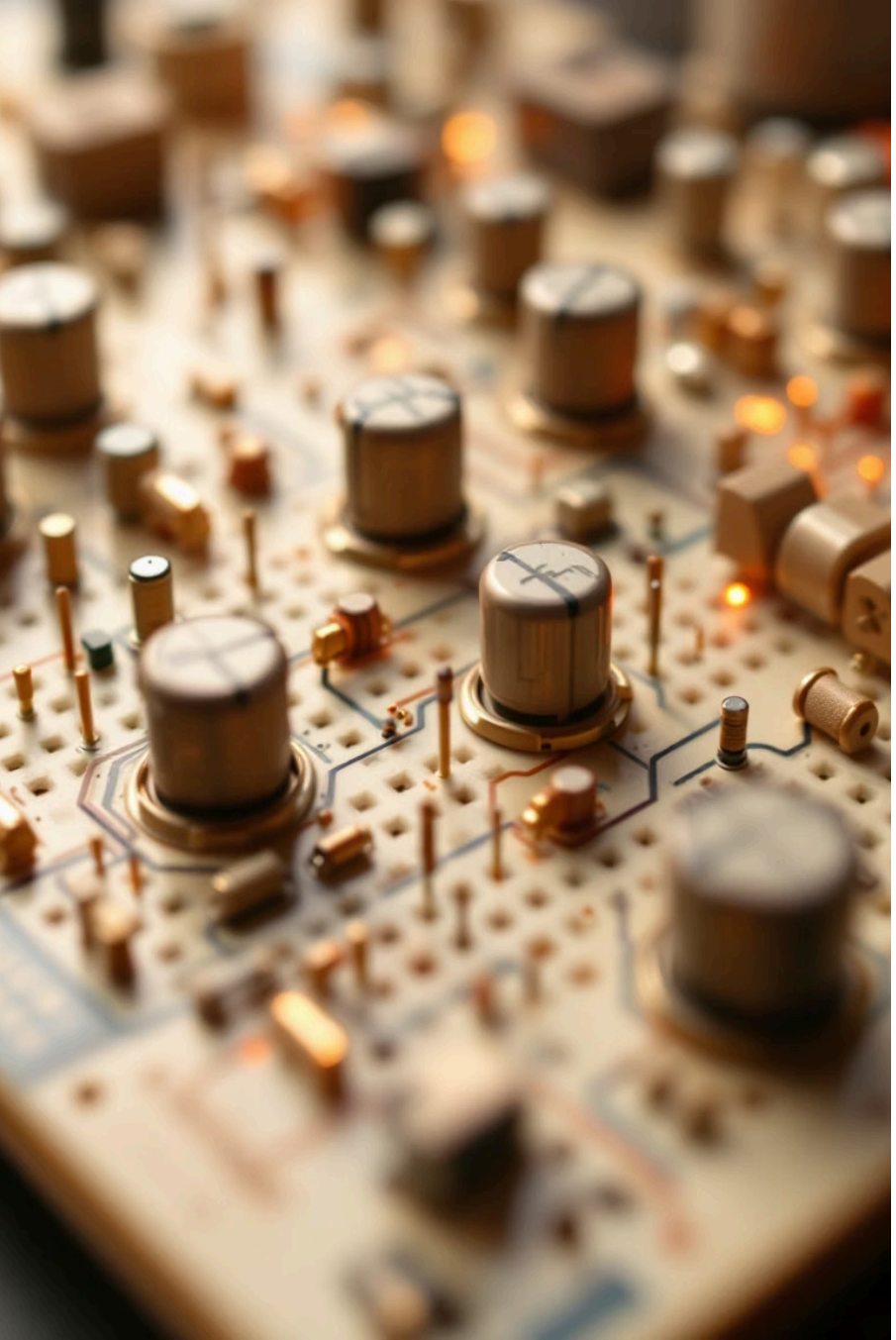
Slew Rate Comparison

Slew Rate Characteristic of the UA741 IC



Slew Rate Measurement for Our Custom Op Amp





Building the Differential Input Stage

Purpose

Amplifies difference between two inputs while rejecting common signals.

Components

Pairs of matched transistors for balanced operation.

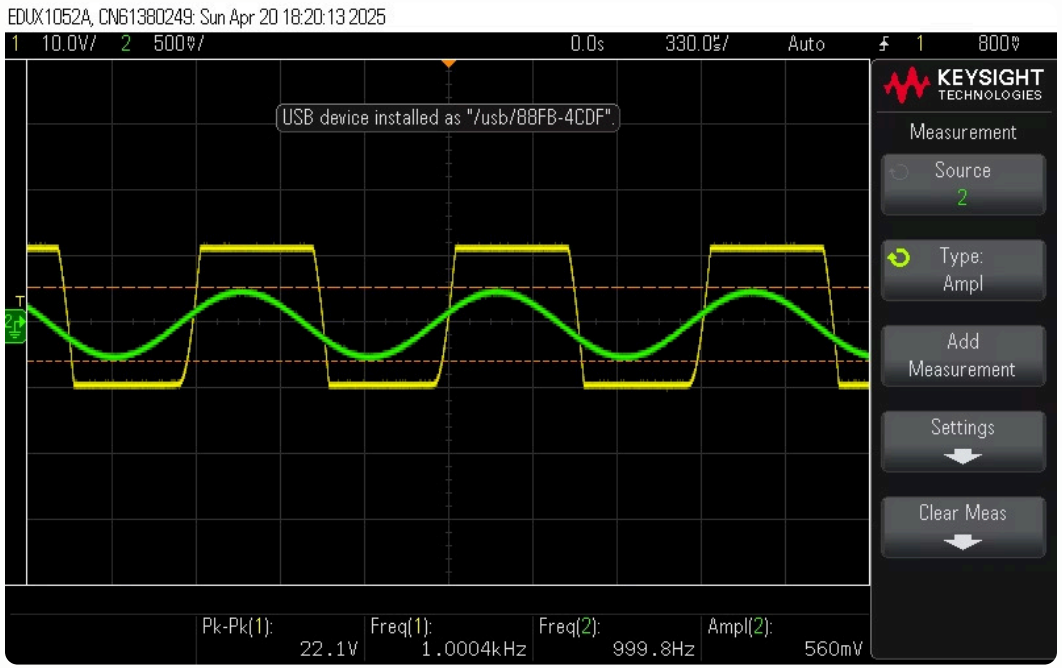
A current source made out of transistor and a diode

Applications of Op-Amp

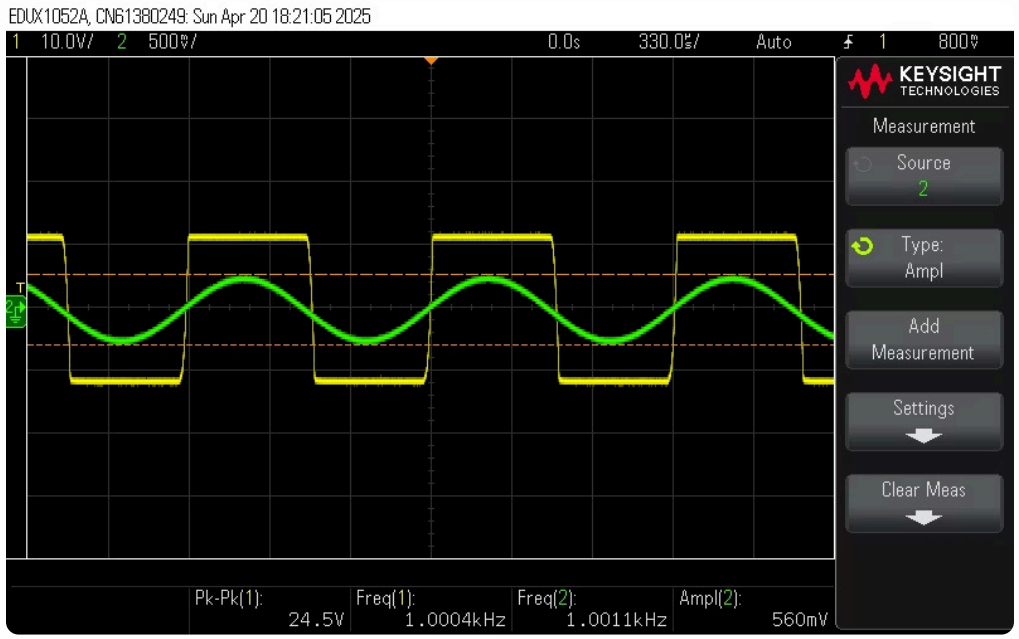
- **Integrator:** Converts input signal into an integrated output over time.
- **Differentiator:** Produces output proportional to input signal rate of change.
- **Half Wave Rectifier:** Allows one polarity of signal to pass, blocking the other.
- **Comparator:** Compares two voltages and outputs a digital signal.
- **Voltage Follower (Buffer):** Provides high input impedance with unity gain, isolating circuits.

Comparator circuit

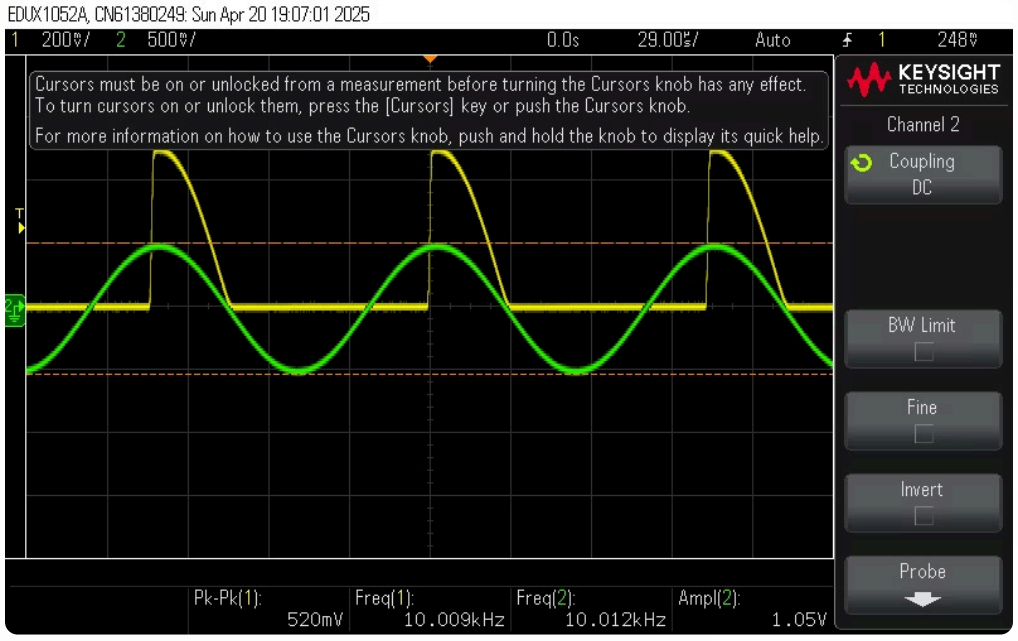
UA741 IC

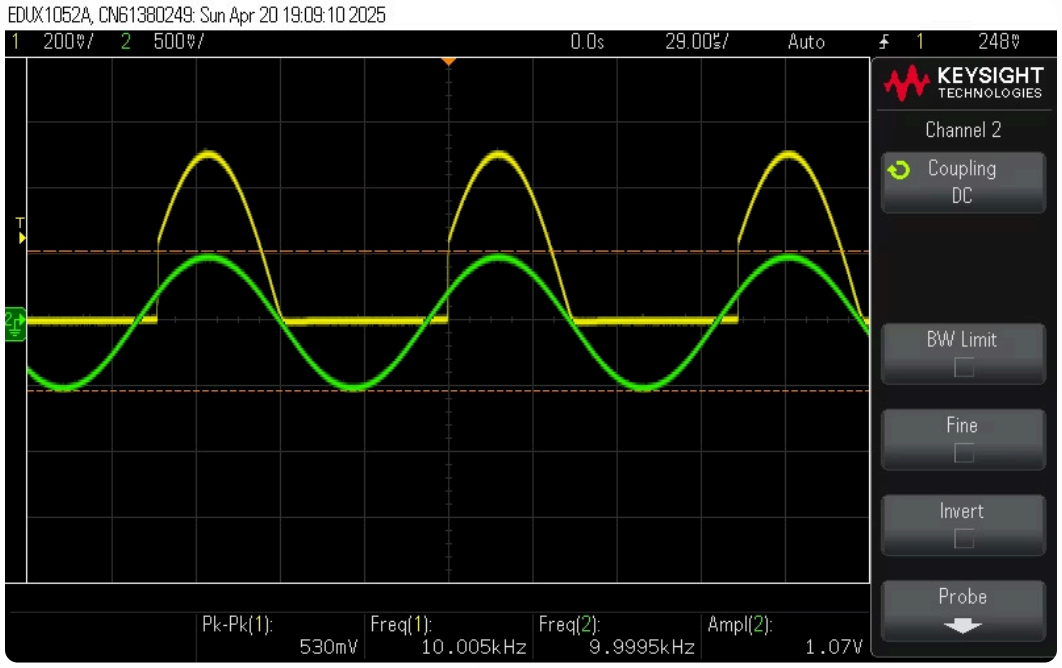


Our op amp



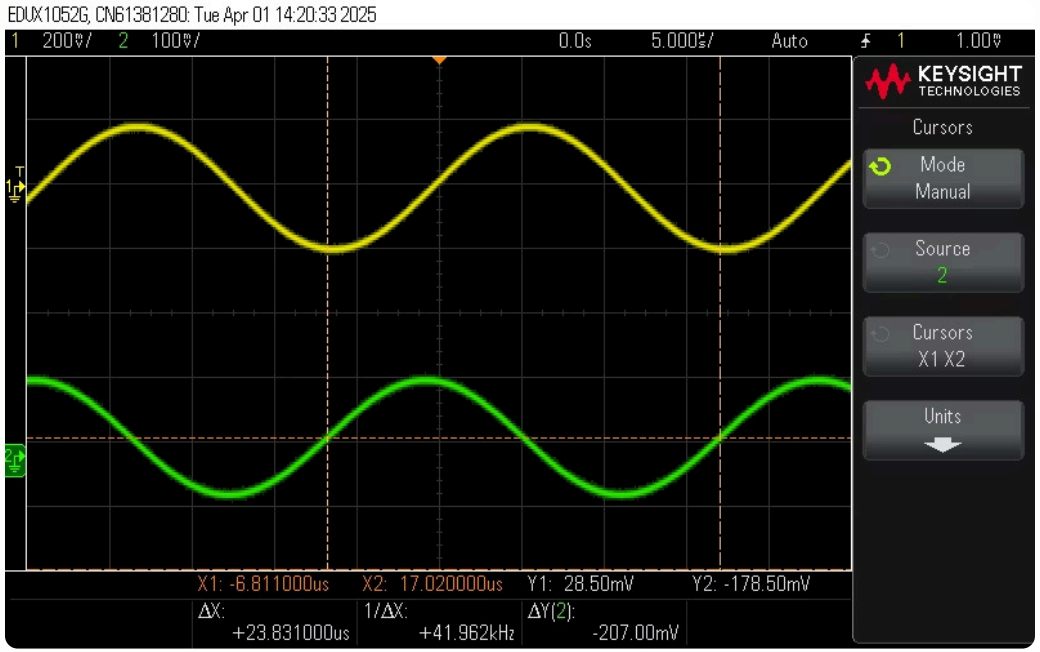
Half wave rectifier comparison



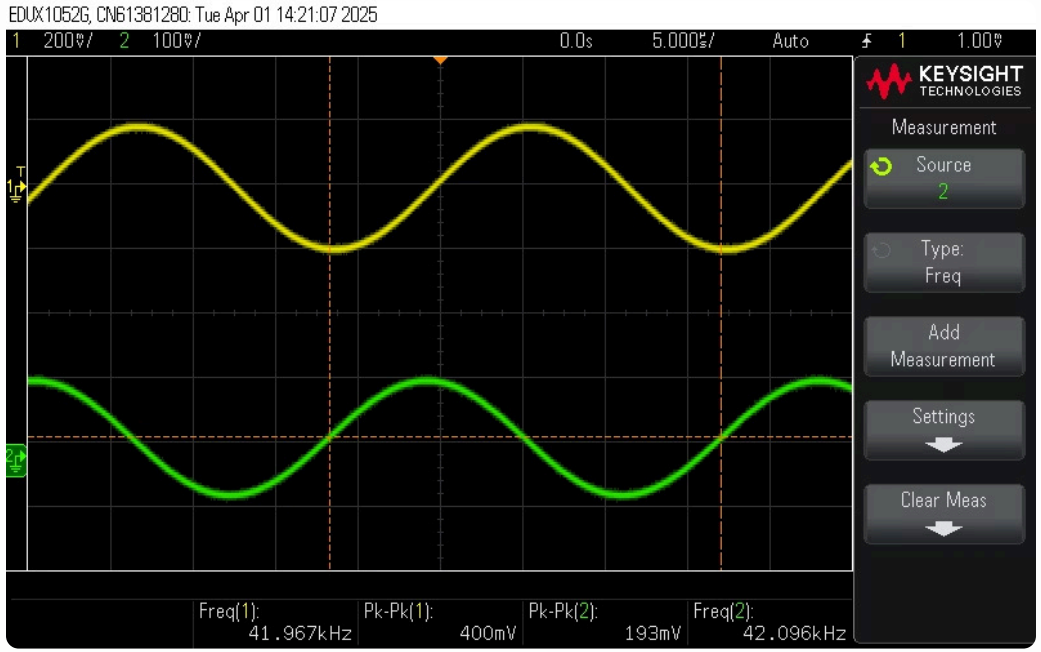


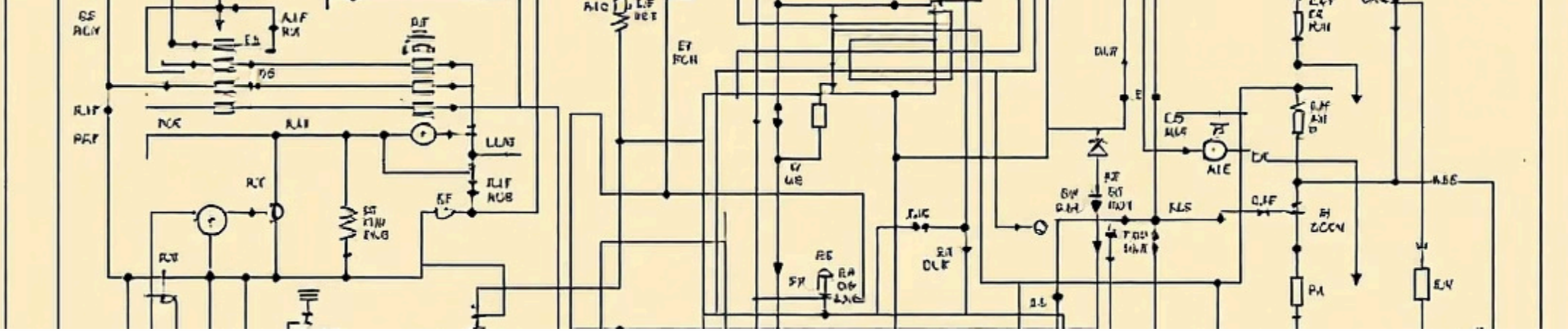
Integrator cirucit

UA741 IC



Our OP amp





High-Gain Intermediate Stage

Voltage Amplification

Boosts signal amplitude significantly before output stage.

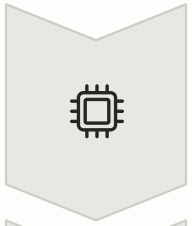
Stability

Includes compensation to avoid oscillation.

Transistor Role

Uses BJT configured for high gain with controlled bias.

Push-Pull Output Stage



Complementary Transistors

Utilizes NPN and PNP to drive output efficiently.

Reduced Distortion

Push-pull design cancels even harmonic distortion.

Current Delivery

Ensures strong output current for driving loads.

Testing and Measurement

Gain Measurement

Checked voltage gain at various frequencies.

Bandwidth Testing

Measured frequency response to confirm design goals.

Output Distortion

Validated low distortion in output signals.

Challenges Encountered

1 **Component Matching**

Difficulty in sourcing perfectly matched transistor pairs.

2 **Thermal Drift**

Temperature fluctuations affected bias stability.

3 **High current**

Many transistors were blown due to high current mainly due to wrong connection