NEURAL DUPLEX RECORDING
ECE 4530
FINAL PROJECT PRESENTATION

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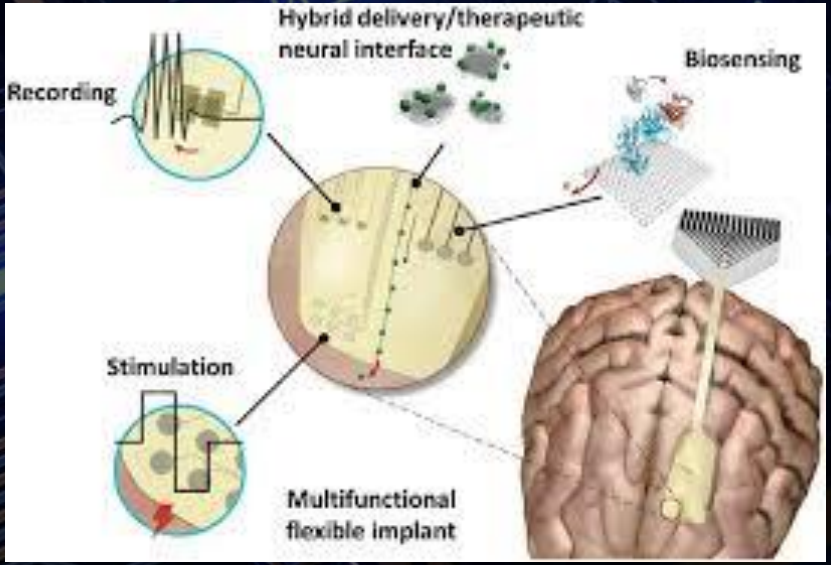
AGENDA

- Introduction
- Specifications
- System Block Diagram
- Subcircuit Breakdown
  - Pre-Cancellation Circuits
  - Difference Circuit
  - Amplifier Circuit
- Performance

INTRODUCTION

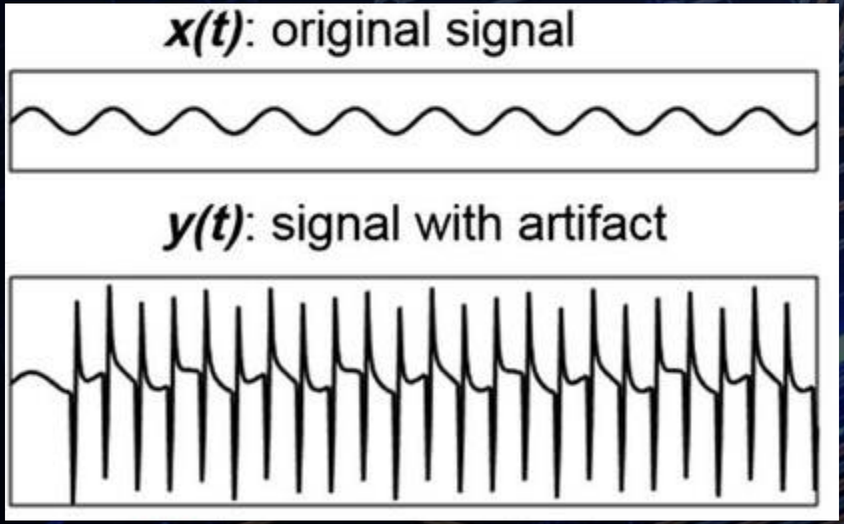
• WHAT IS NEURAL DUPLEX?

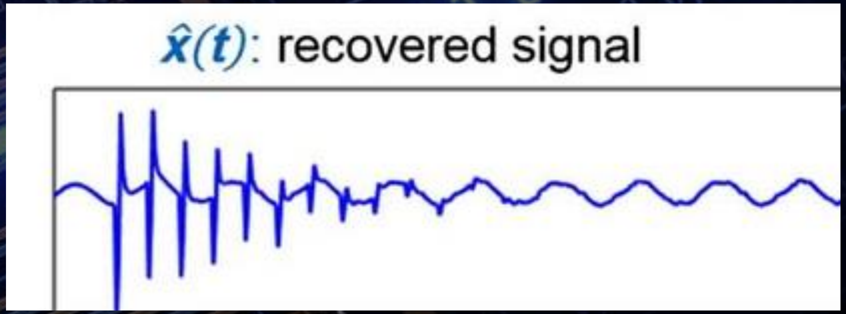
- The neural duplex system enables the stimulation and measurement of neural activity simultaneously.
- Neural duplex can help us better understand the brain and nervous system, which can help improve clinical therapy of neurological disorders related to brains such as Parkinson's disease and depression.
- Currently, the neural duplex is still a research topic



• Challenges of the Neural Duplex

- A large artifact generated through the direct coupling of the simulation signal and recording probe
- Need to cancel the artifact before passing the signal through the amplifier so the circuit doesn't saturate



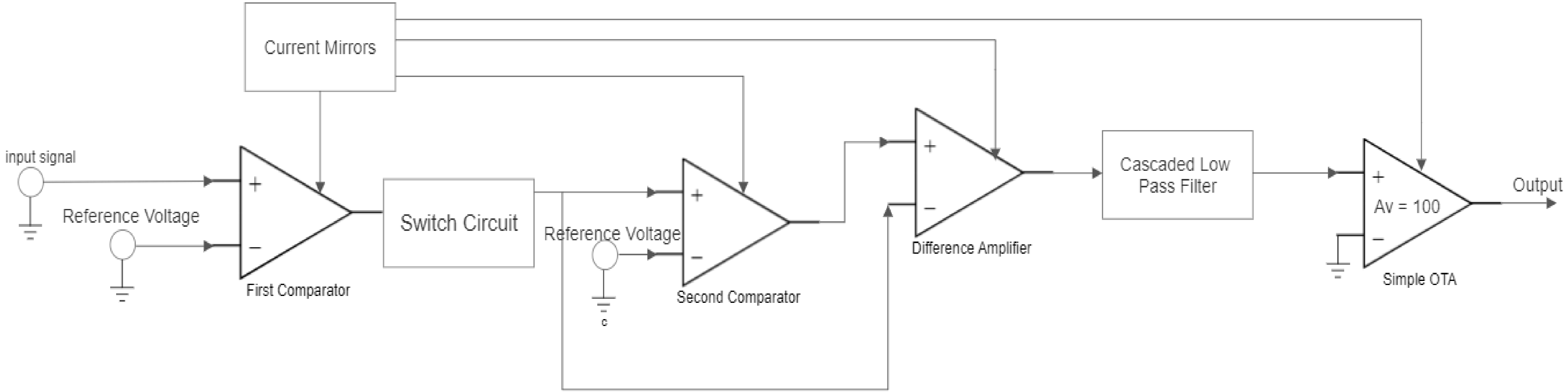


• Specifications

- The table below summarizes the specifications for our design:

Parameter	Value	Unit
Gain	40	dB
Bandwidth	10	KHz
Input signal	100	uV
Noise	10	uV
Power Consumption	100	uW
Suppressed Artifact (at the output)	<1	V

• System Block Diagram

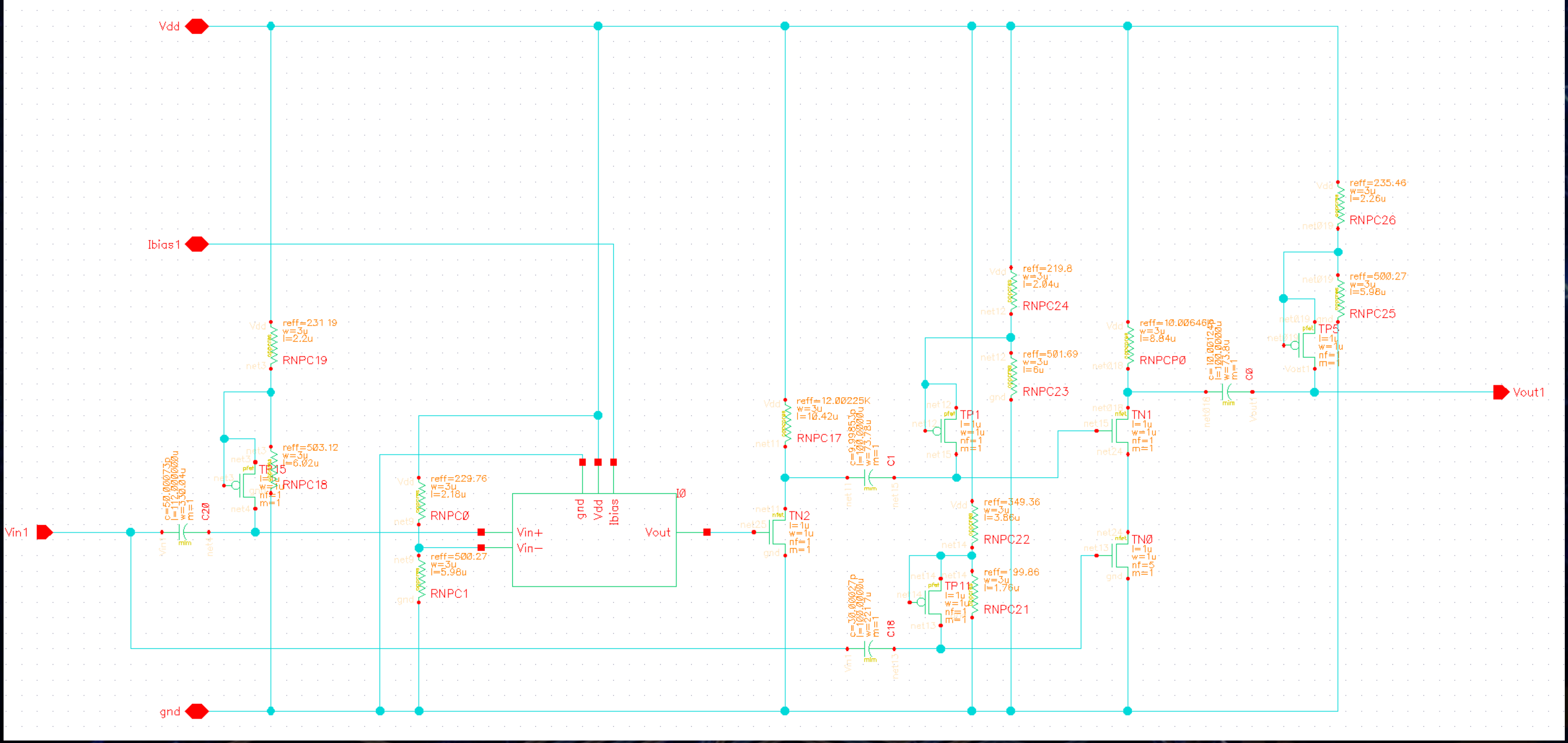


SUB-CIRCUIT BREAKDOWN

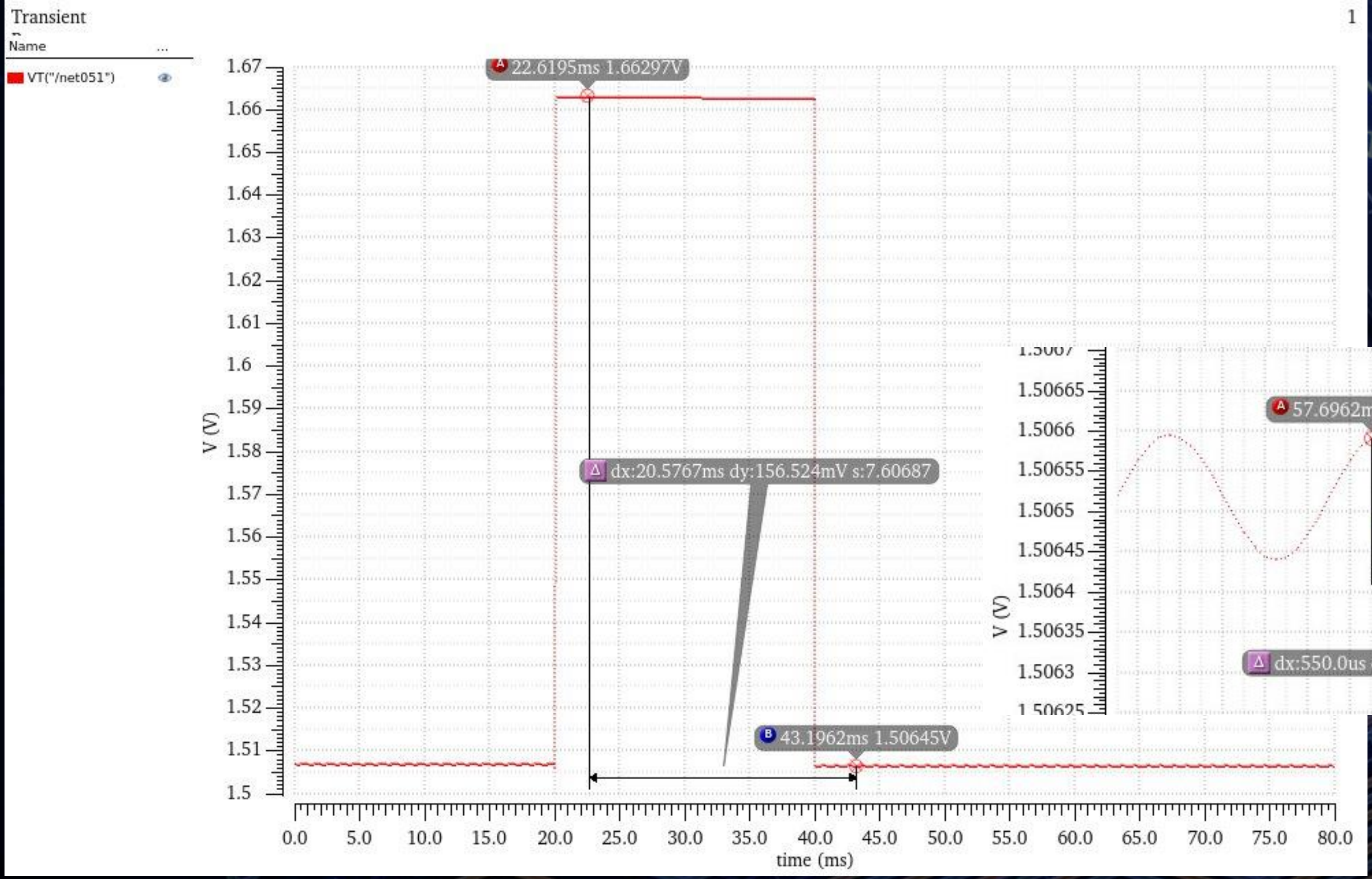
• Pre-Cancellation Circuit

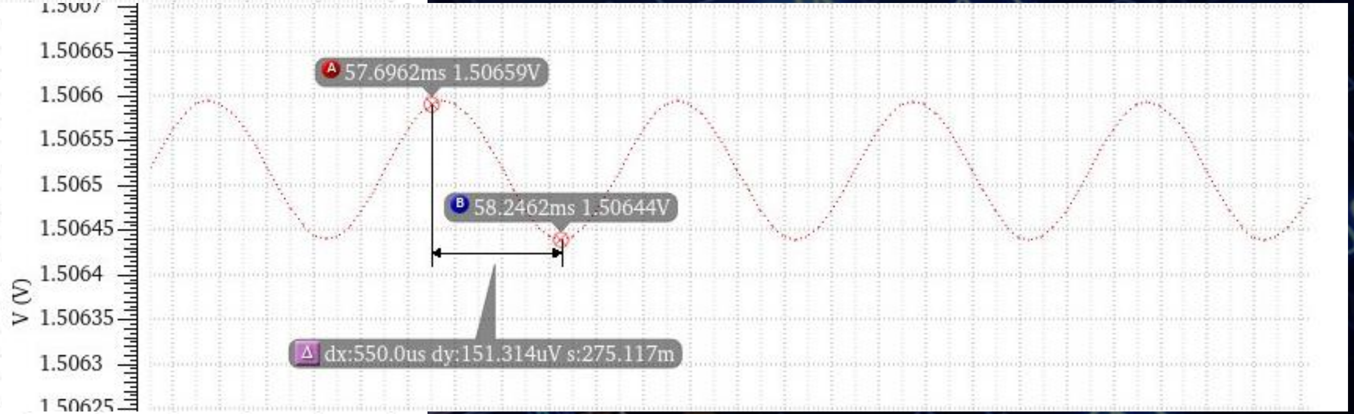
- Generates the two inputs into the difference amplifier
- Use a PFET as a switch in a common gate configuration; inverted comparator output as gate voltage
- The comparator circuit output is either Vdd or GND based on the reference voltage
- A second comparator generates a square pulse to match the output of the switch circuit

• Pre-Cancellation Circuit: Schematics



• Pre-Cancellation Circuit: Simulation

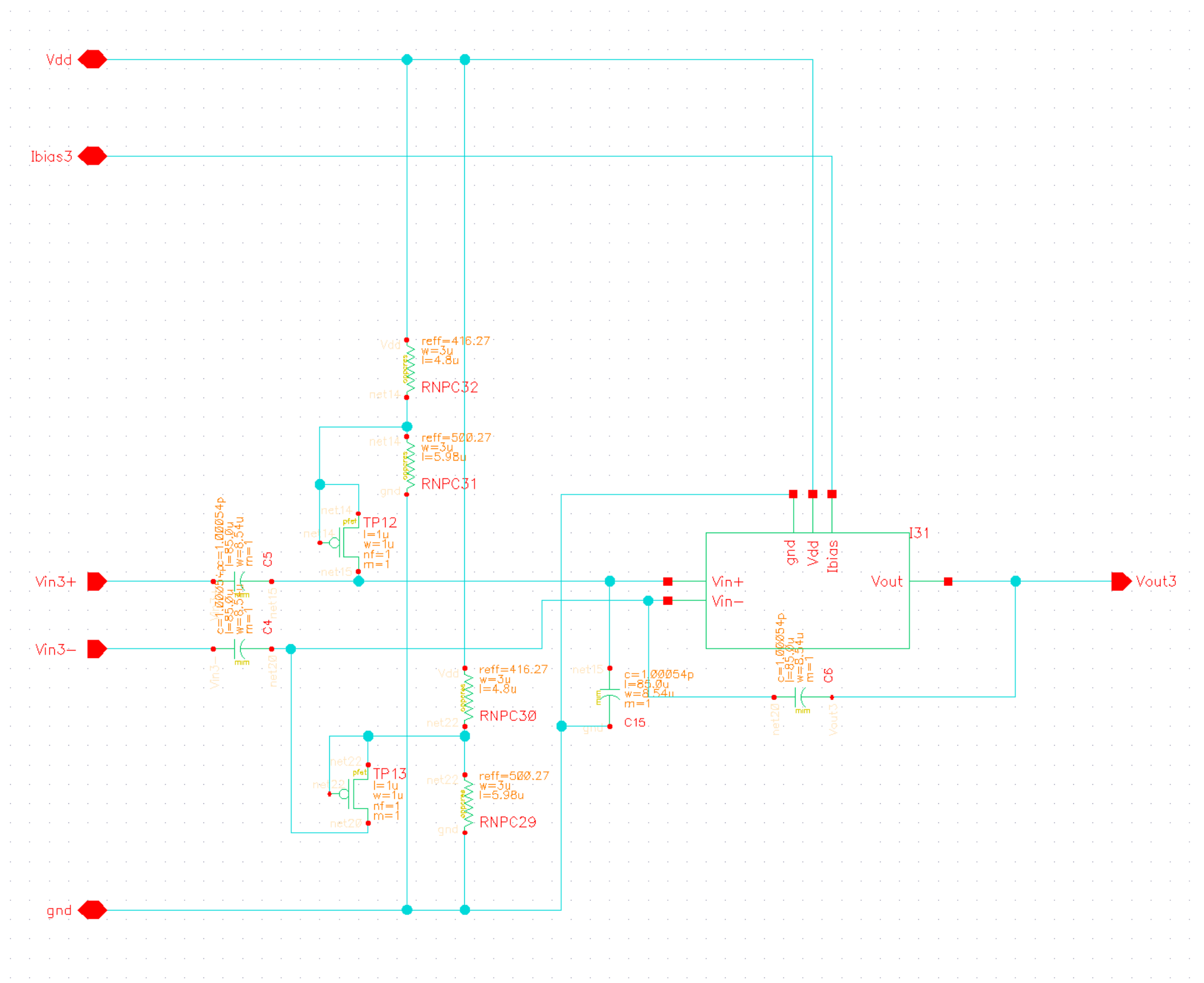


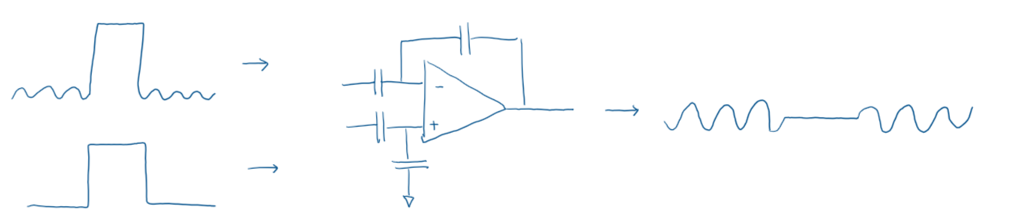


- Amplitude of the square wave is 156.52mV
- Amplitude of the sine wave is 151.3uV

• DIFFERENCE AMPLIFIER

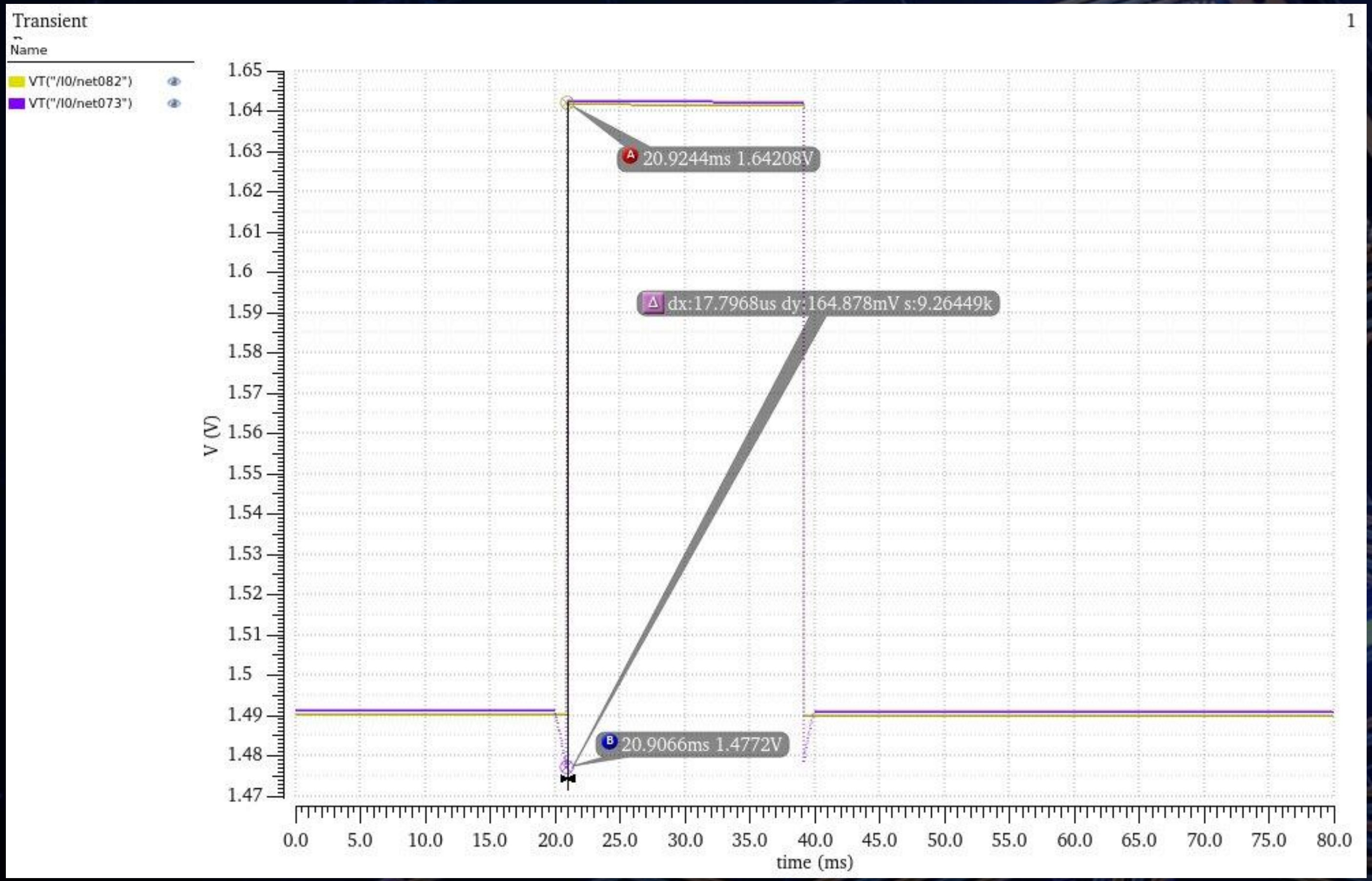
- Takes the outputs from the two pre-cancellation circuits as inputs and subtracts the two signals as part of the cancellation.
- Cancels the square-wave pulse in the output of the switch.

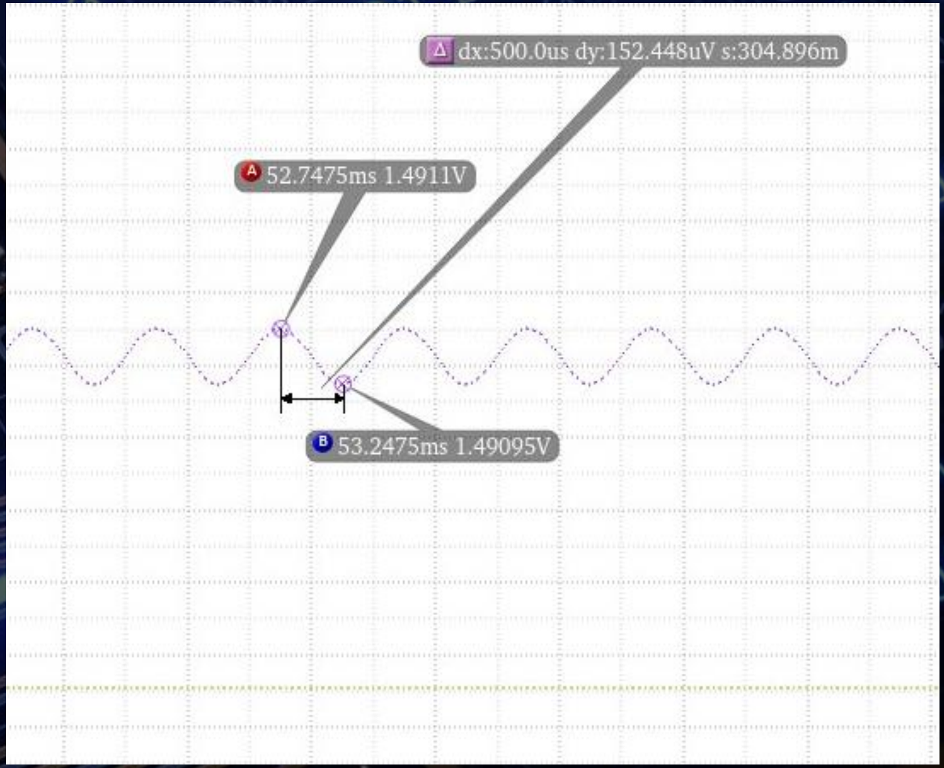




• Difference Amplifier: Simulation

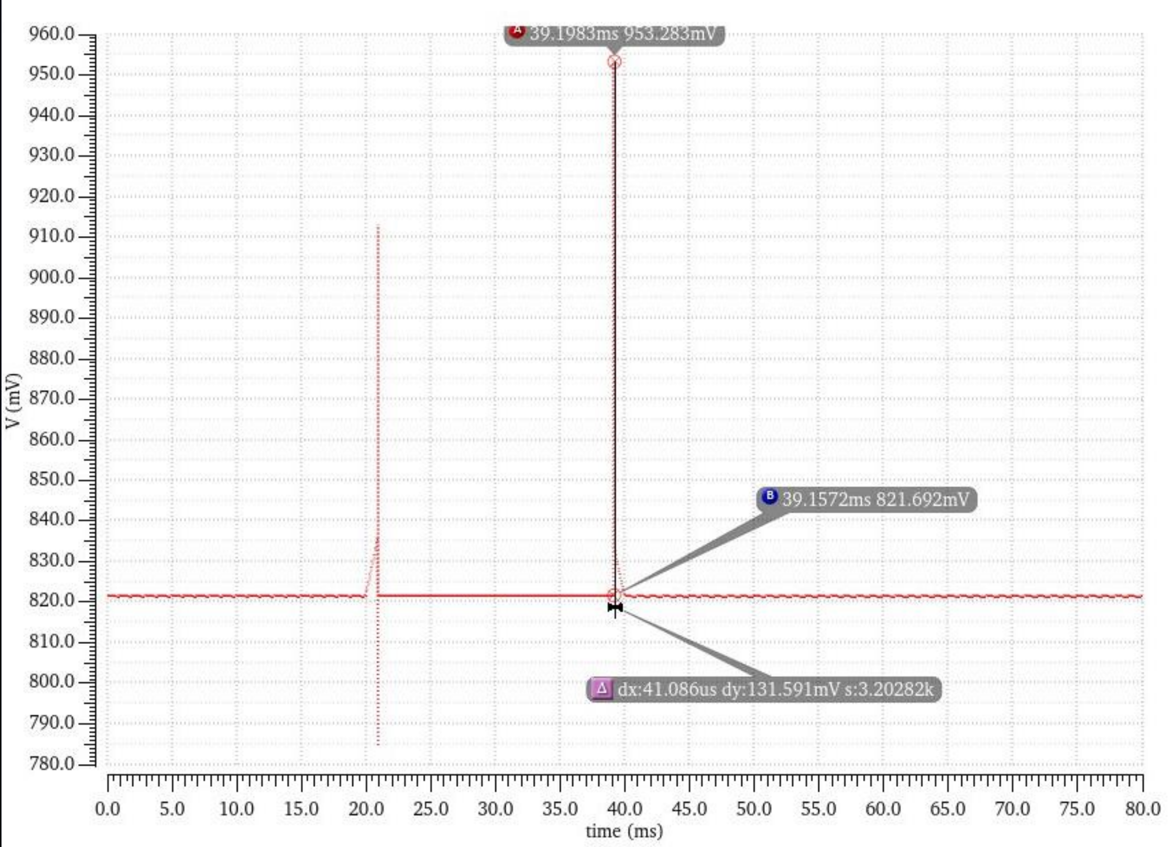
Input Signals: Vsin = 152.uV; Vsquare = 164.9mV;



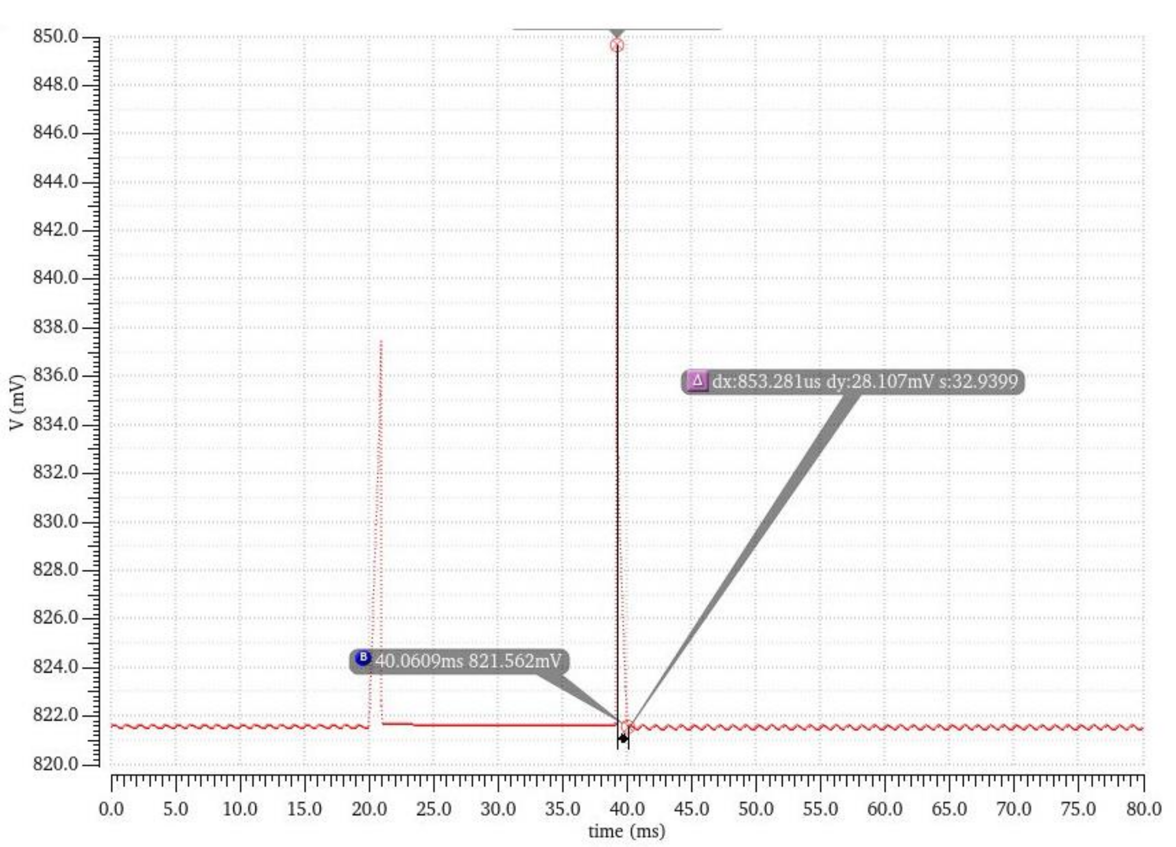


• Difference Amplifier: Simulation

Output Before Filtering (131mV)

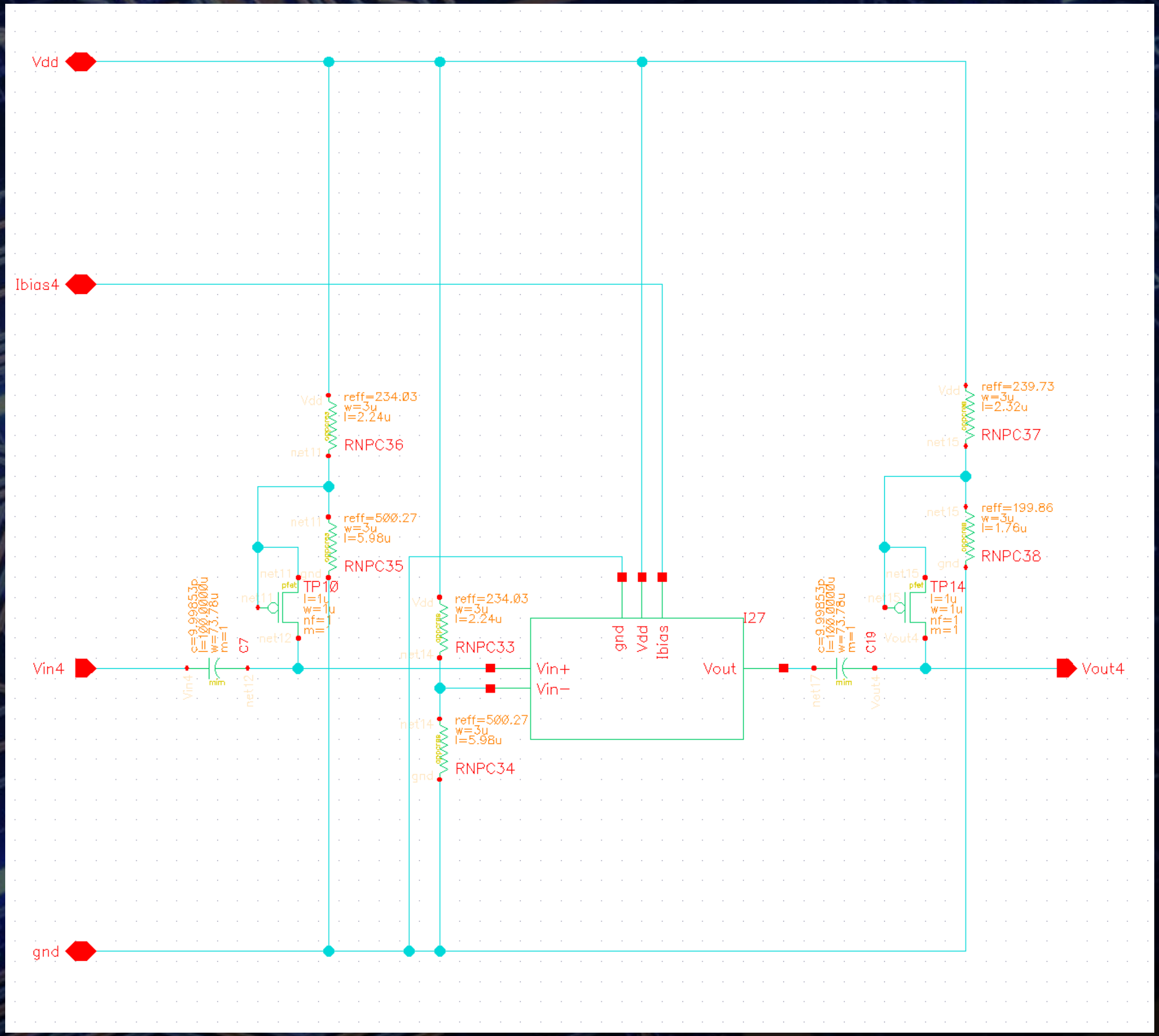


Output After Filtering (28mV)



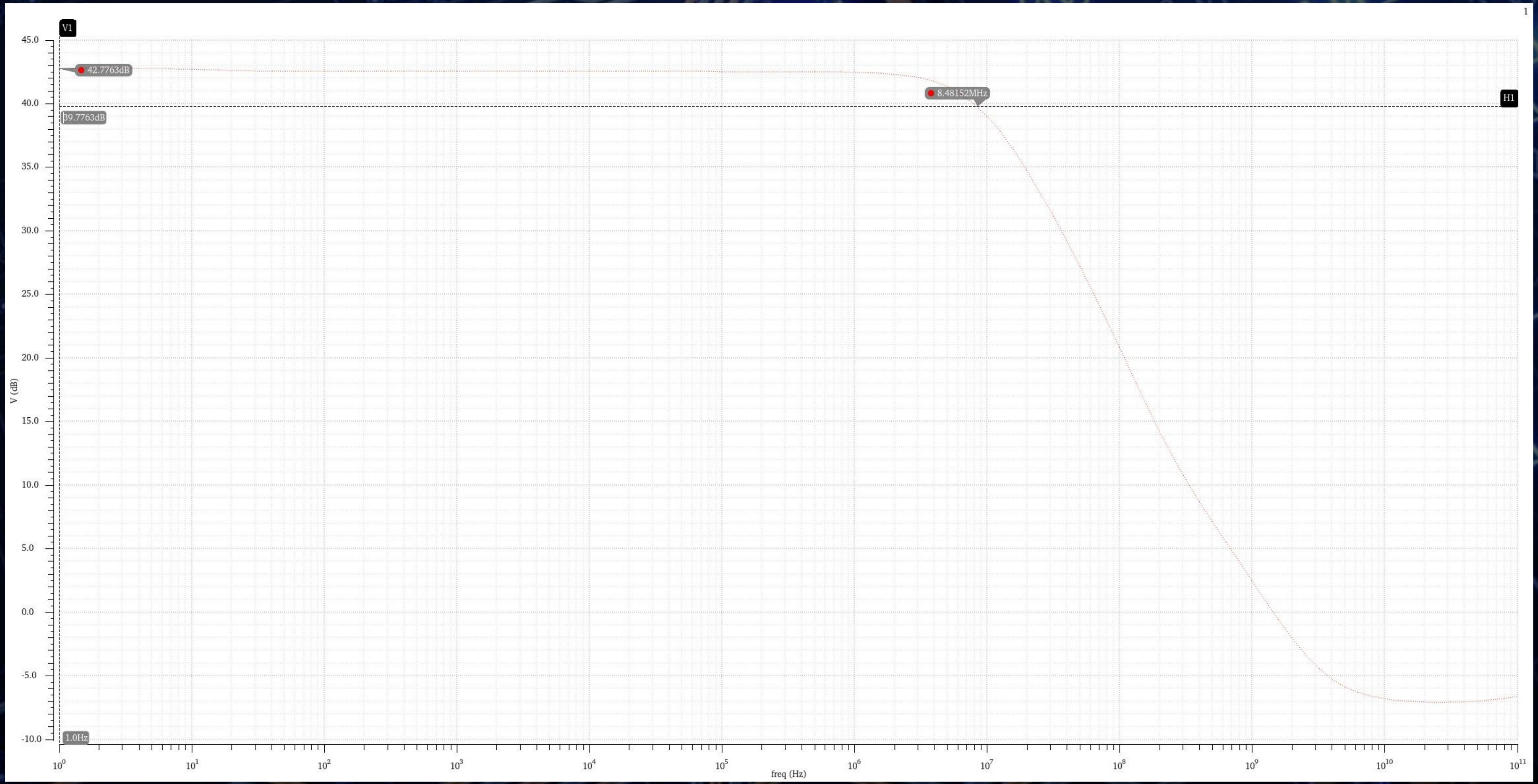
• SIMPLE OTA

- We have a simple OTA to amplify the signal since we don't need a high gain

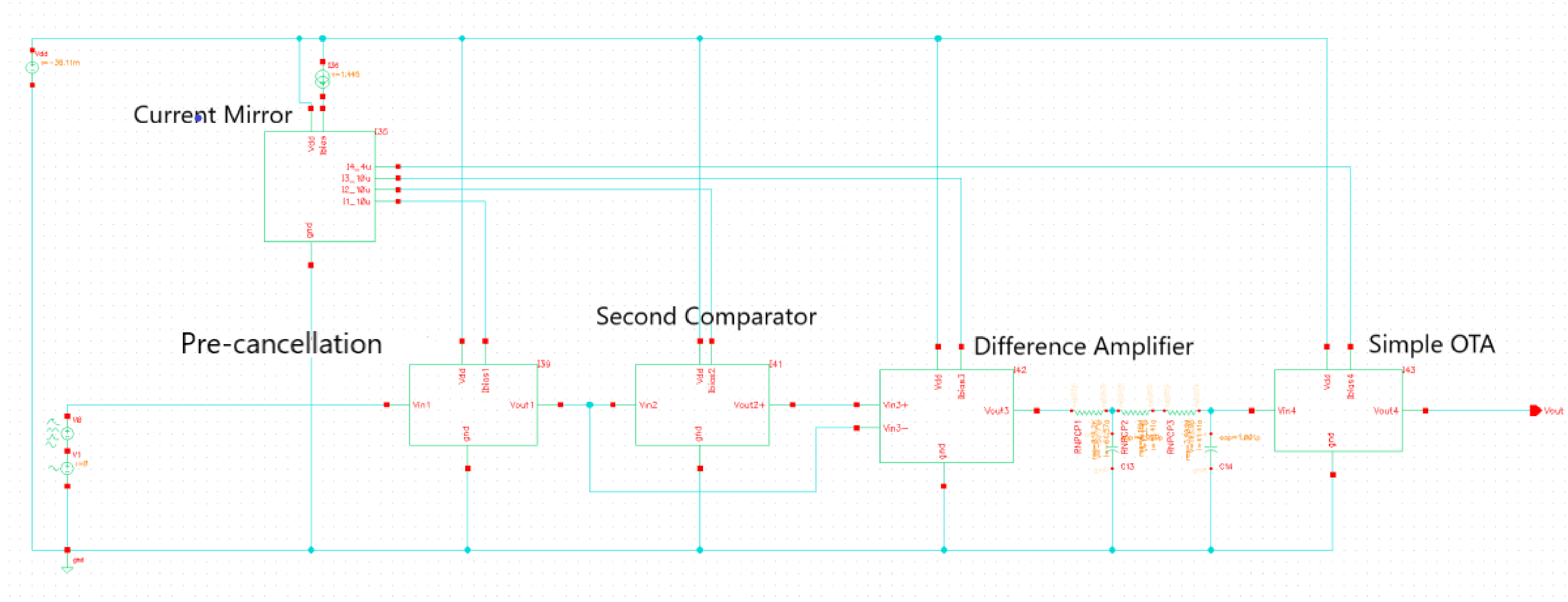


• SIMPLE OTA: SIMULATION

- AC simulation of the simple OTA showing gain and bandwidth (Av= 42.78dB, BW= 8.48MHz)

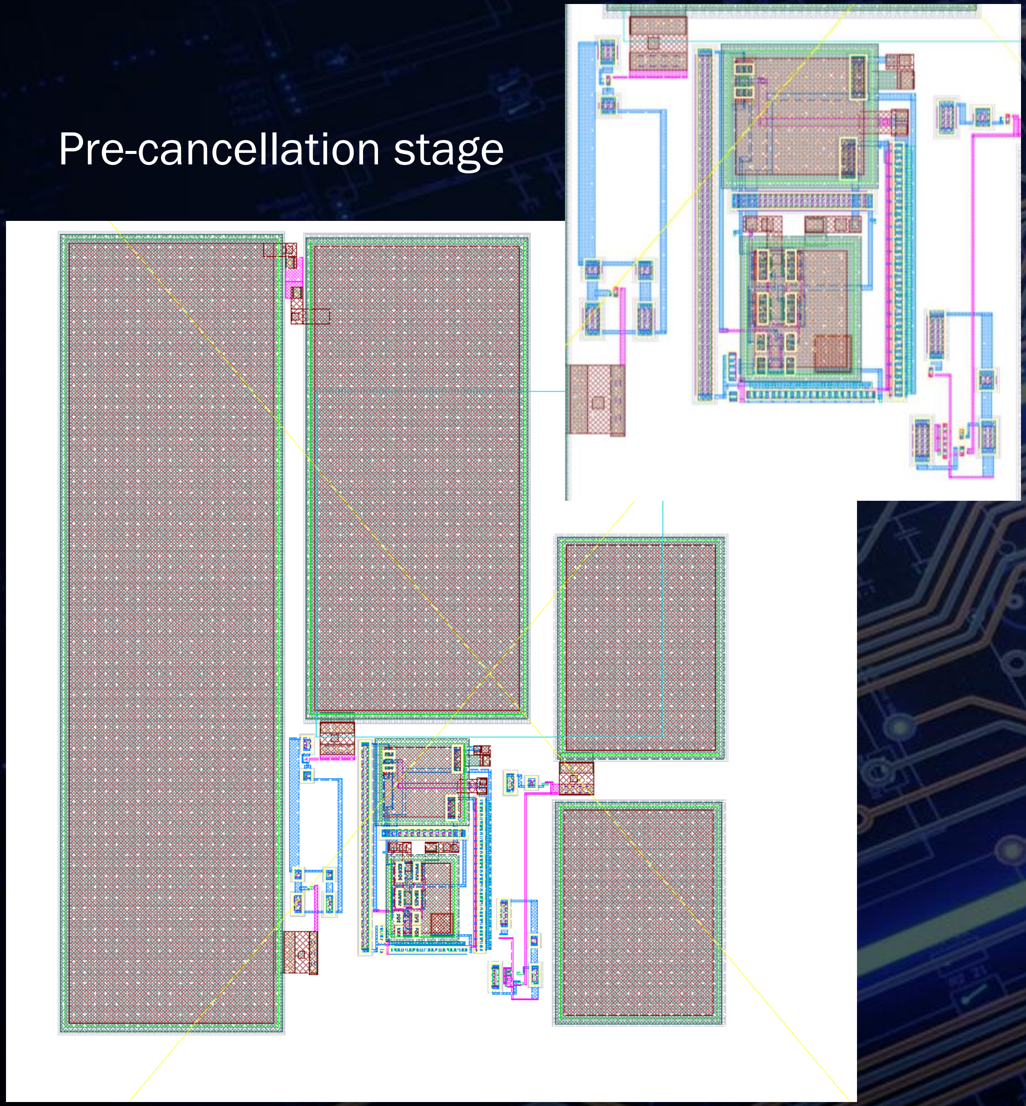


- # TOP LEVEL CIRCUIT

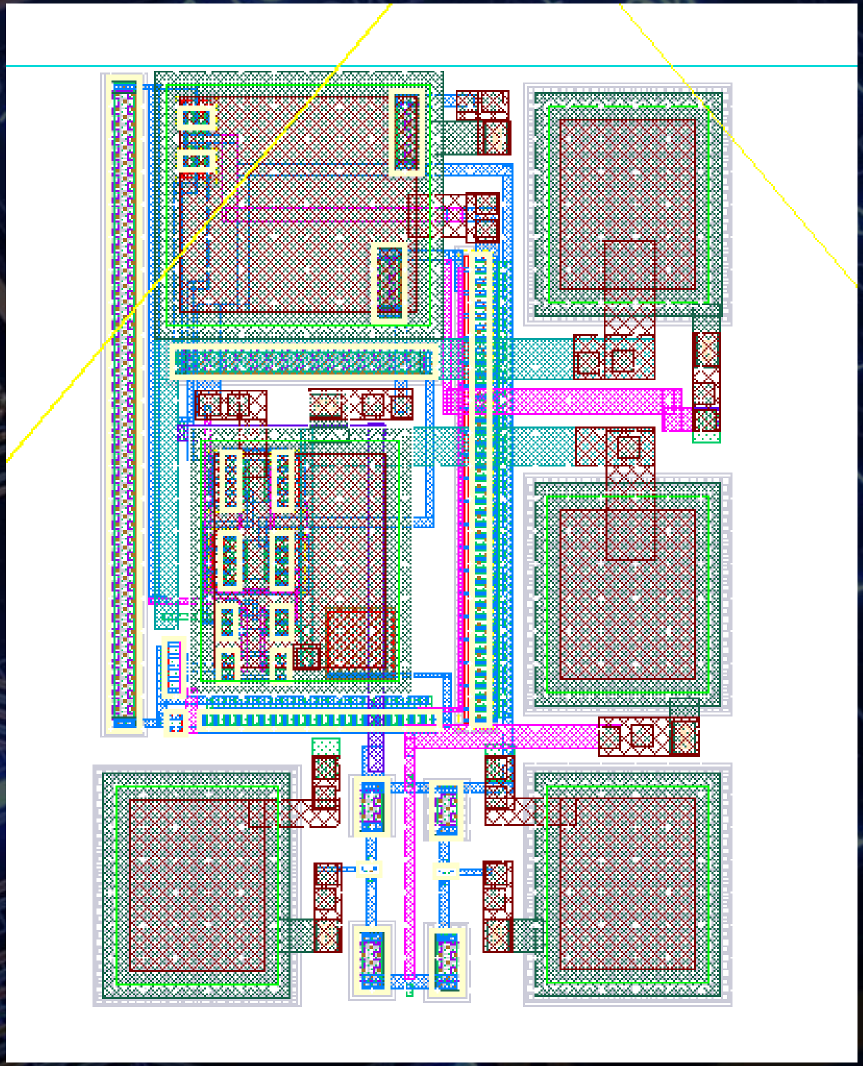


• TOP LEVEL LAYOUT (IN PROGRESS)

Pre-cancellation stage

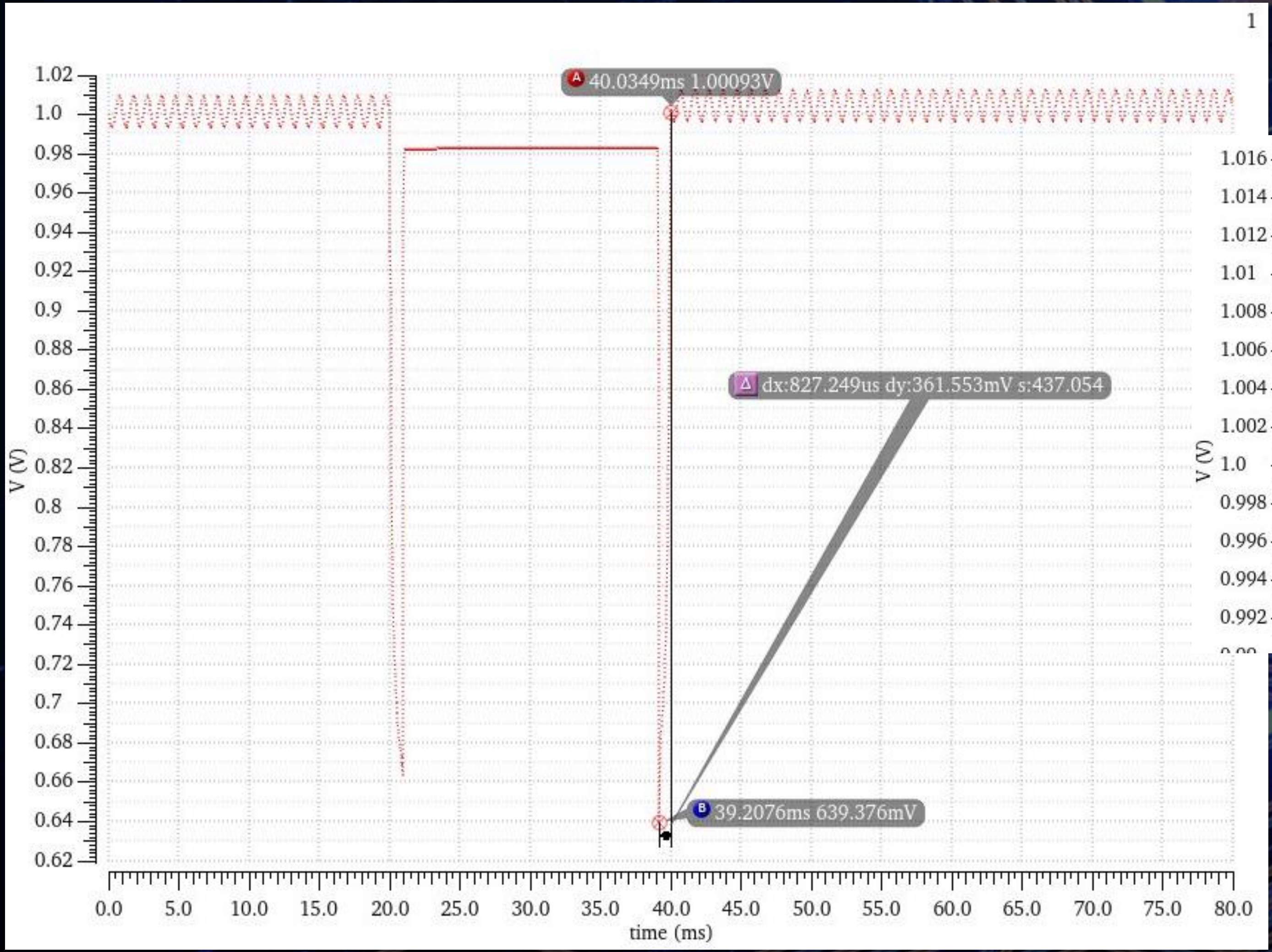


Cancellation stage

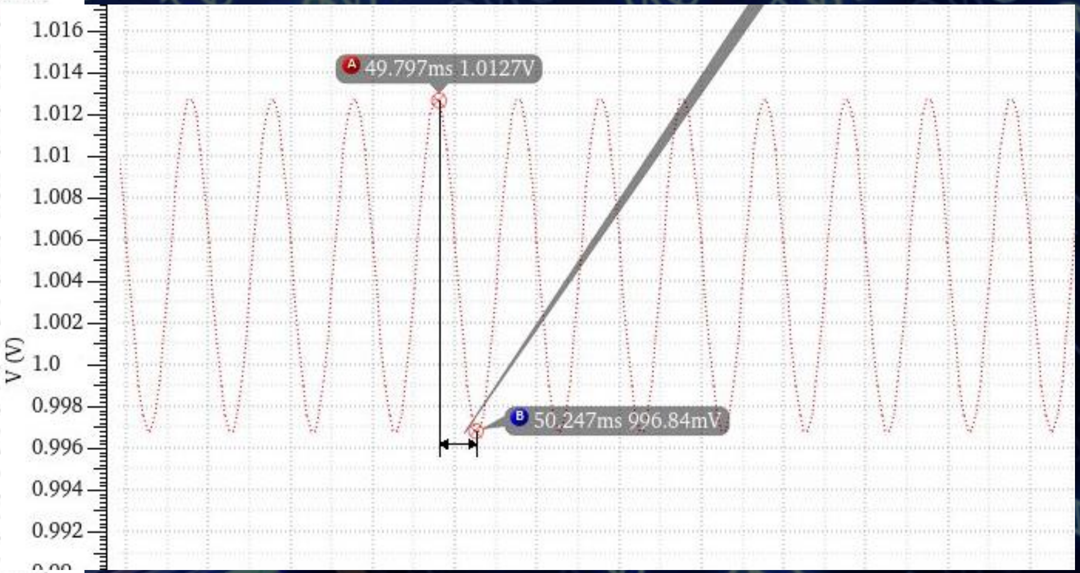


PERFORMANCE

Performance: Cancellation & Amplification



Input:
Vsin = 50uV
Vpeak = 100 mV



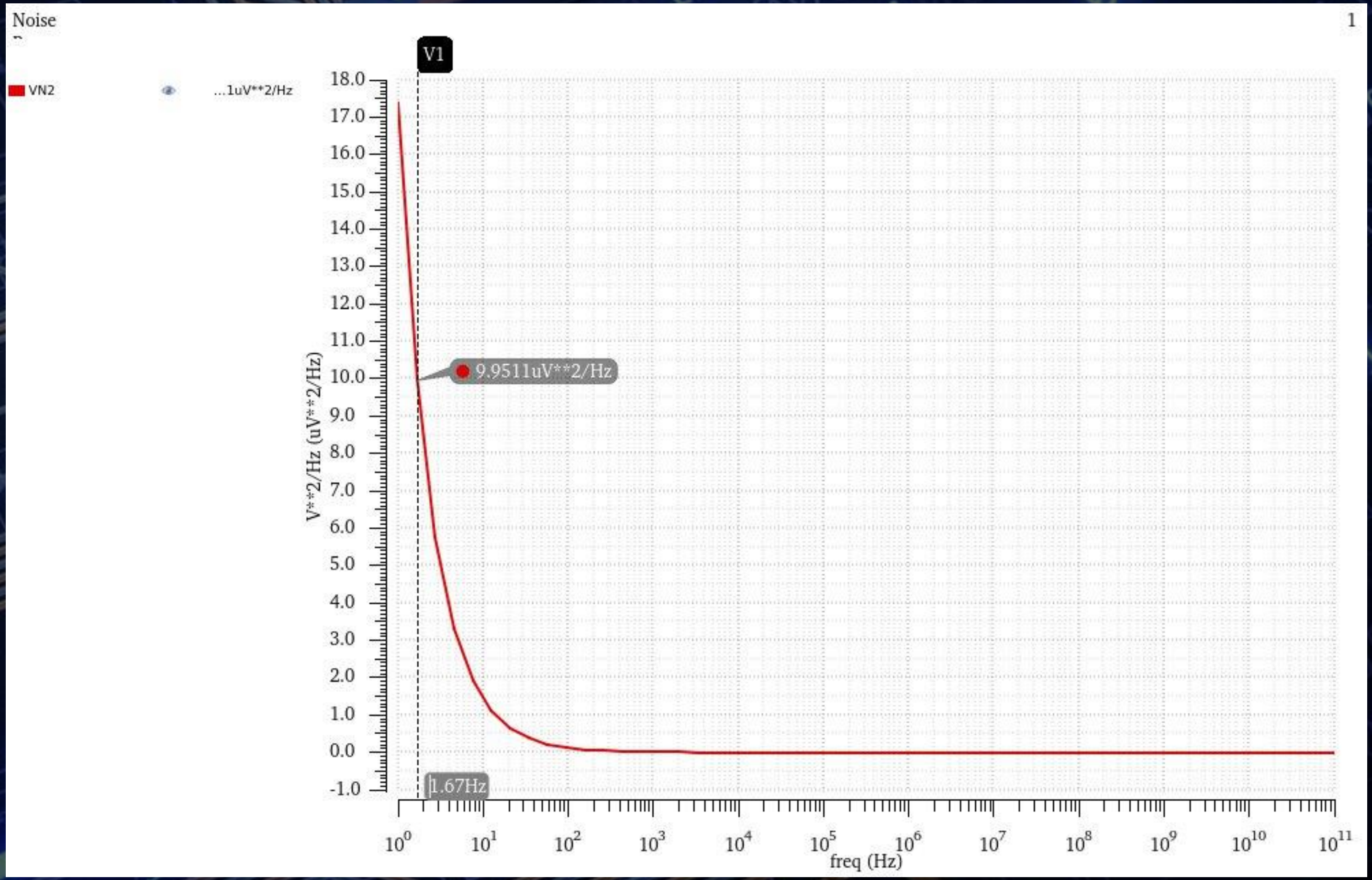
Output:
Vsin = 15.8mV
Vpeak = 361.553 mV

• Performance: Power

- We have four sub-circuits in our system. We calculate the power for each sub-system separately.
- Power consumption
  - First comparator & second comparator: p = 127uW
    - P,switch circuit = 36 uW
  - Difference amplifier: p = 139uW
  - Simple OTA: p = 64uW
  - The biasing circuits consume a lot of power, but they could be optimized

• PERFORMANCE: NOISE

- The picture to the right shows our output noise of the whole system.
- The noise is below 10 uV/Hz when the frequency is above 1.7 Hz



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THANK YOU!

QUESTIONS?