# Indian Institute of Technology Bombay

# Analog Circuits Lab
# EE 230

**Lab 3**
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# Contents

# 1 Center Tapped Full-Wave Rectifier

## 1.1 Aim of the experiment

1. To design and analyze a center-tapped full-wave rectifier circuit.
2. To observe the waveforms of the input signal ($V_{in}$) and the rectified output ($V_{out}$).
3. To measure and calculate the ripple amplitude in the presence of a smoothing capacitor.

## 1.2 Design

The circuit comprises a center-tapped transformer with a primary-to-secondary turn ratio of 6:1, two 1N4007 diodes in a full-wave configuration, and a load resistor R = 22k$\Omega$. A sinusoidal input signal of 20 $V_{PP}$ at 1kHz is applied to the transformer, and the rectified output ($V_{out}$) is observed at the load. When a 1$\mu$F capacitor is added across the load, it reduces the ripple in the rectified output, which can be calculated using the formula:

$$V_{ripp} = \frac{V_{in1} - V_D}{2fRC} \tag{1}$$

The capacitor charges to the peak voltage minus the diode drop when the diodes are conducting and discharges through R when the diodes are off, causing ripple.

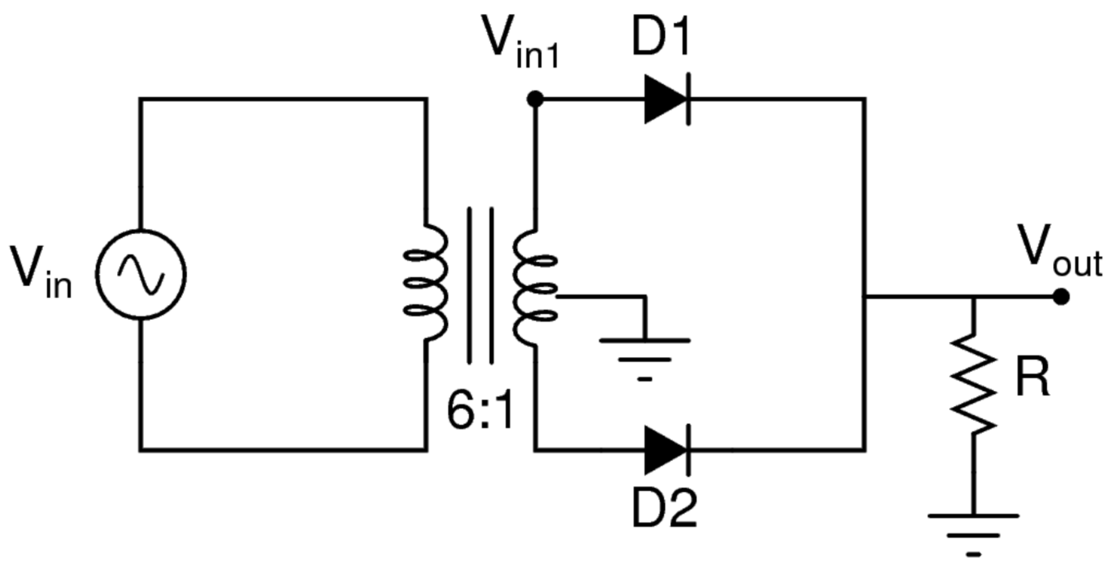


Figure 1: Center Tapped Full Wave Rectifier Circuit

## 1.3 Experimental results

| Sr. No. | Parameter | Value |
|---|---|---|
| 1 | Turn Ratio (given) | 6:1 |
| 2 | Turn Ratio (measured) | 6.02:1 |
| 3 | Diode Drop | 0.245 V |
| 4 | Frequency | 1856 Hz |
| 5 | $V_{ripp}$ (measured) | 8 mV |
| 6 | $V_{ripp}$ (calculated) | 7 mV |

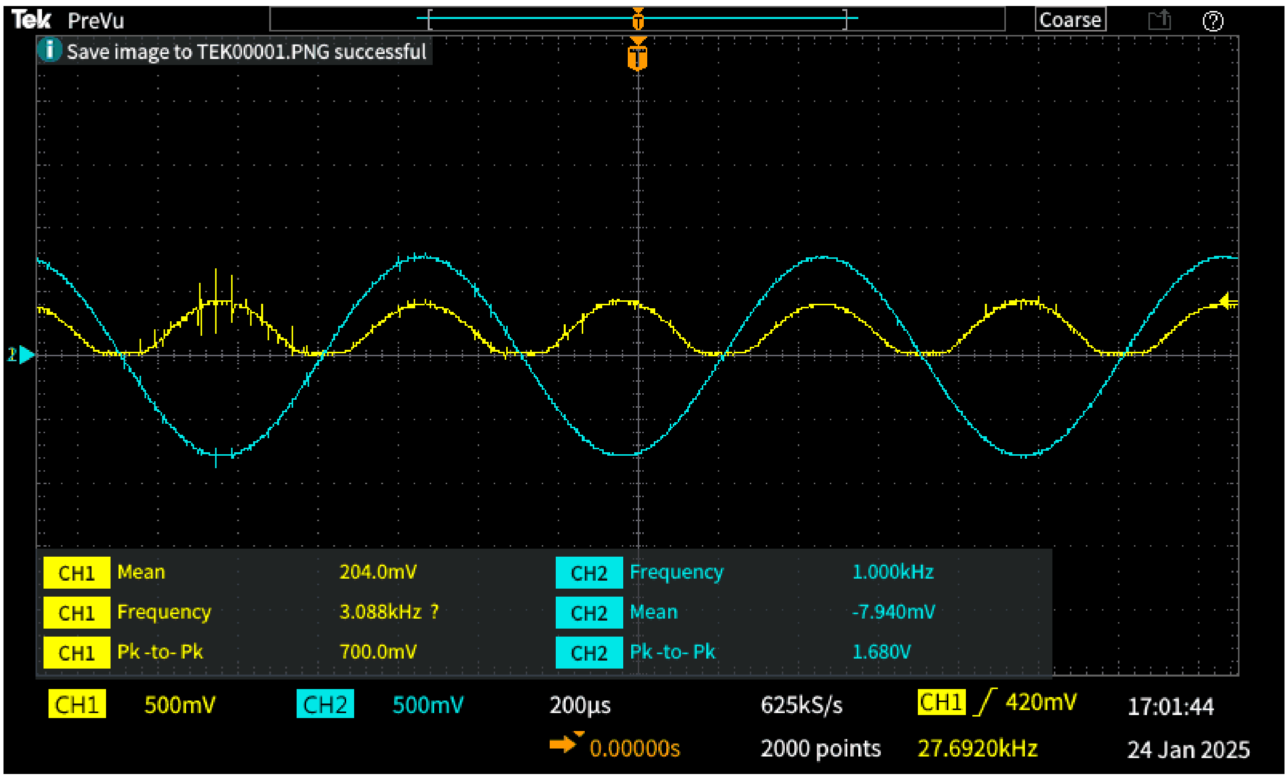


Figure 2: $V_{out}$ and $V_{in}$ Waveforms

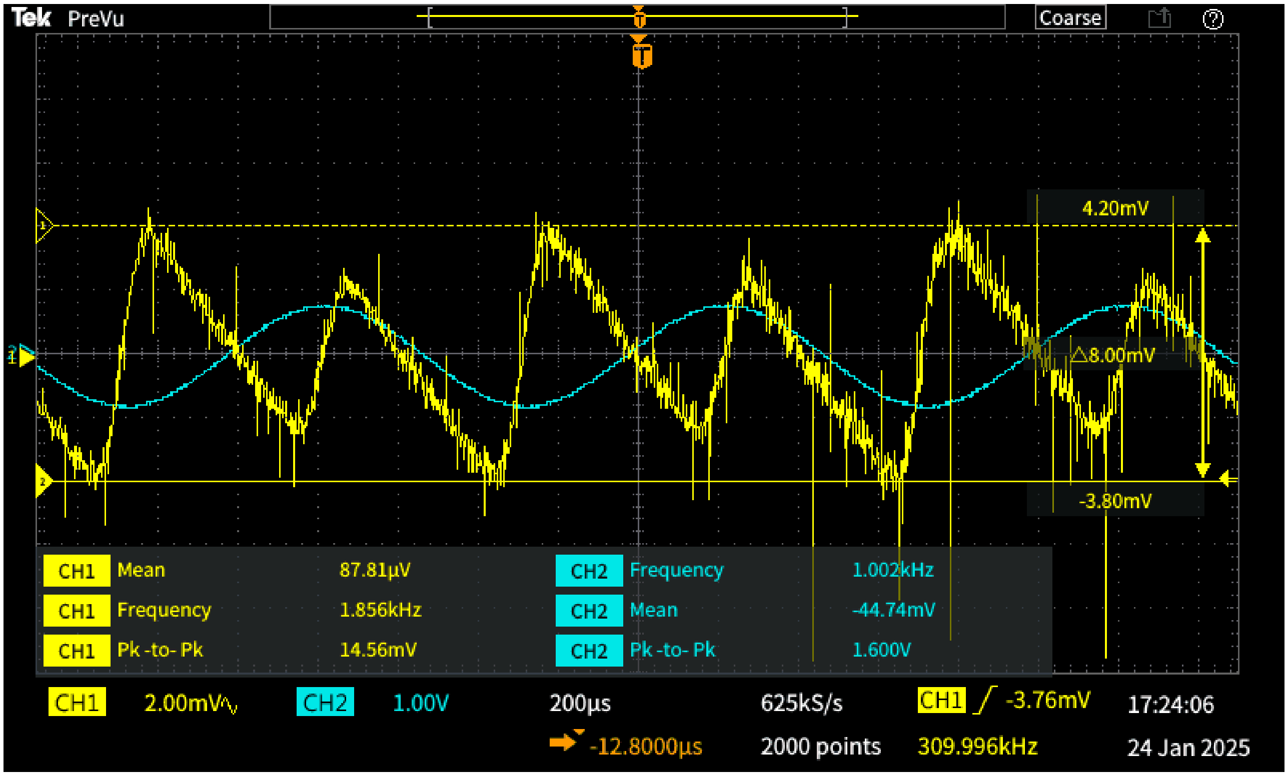


Figure 3: Ripples after adding capacitor

## 1.4 Conclusion and Inference

1. The voltage difference between the peak voltage of $V_{in1}$ and $V_{out}$ is because of the diodes i.e. it corresponds to the diode drop.

# 2 Full Wave Precision Rectifier

## 2.1 Aim of the experiment

1. To design and implement a full-wave precision rectifier circuit using operational amplifiers.
2. To compare its behavior with a center-tapped rectifier and examine its advantages in terms of accuracy for small input signals.

## 2.2 Design

The circuit employs an operational amplifier to eliminate the diode's forward voltage drop, enabling precise rectification of small signals. The experiment starts with a half-wave rectifier using an op-amp and a single diode to observe the rectified output for an input sinusoid of $2V_{PP}$ at 1kHz. The circuit is then extended to a full-wave rectifier by adding an additional OpAmp and diode configuration. The outputs ($V_o$) of the precision rectifier are compared to the center-tapped rectifier, showing no significant loss in peak voltage due to the absence of $V_D$.

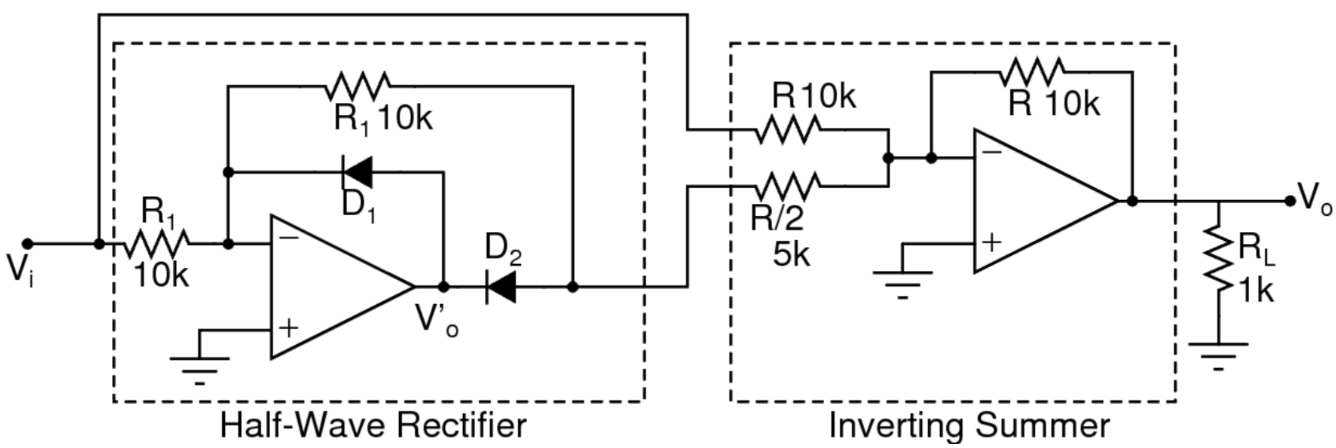


Figure 4: Full Wave Precision Rectifier

## 2.3 Experimental results

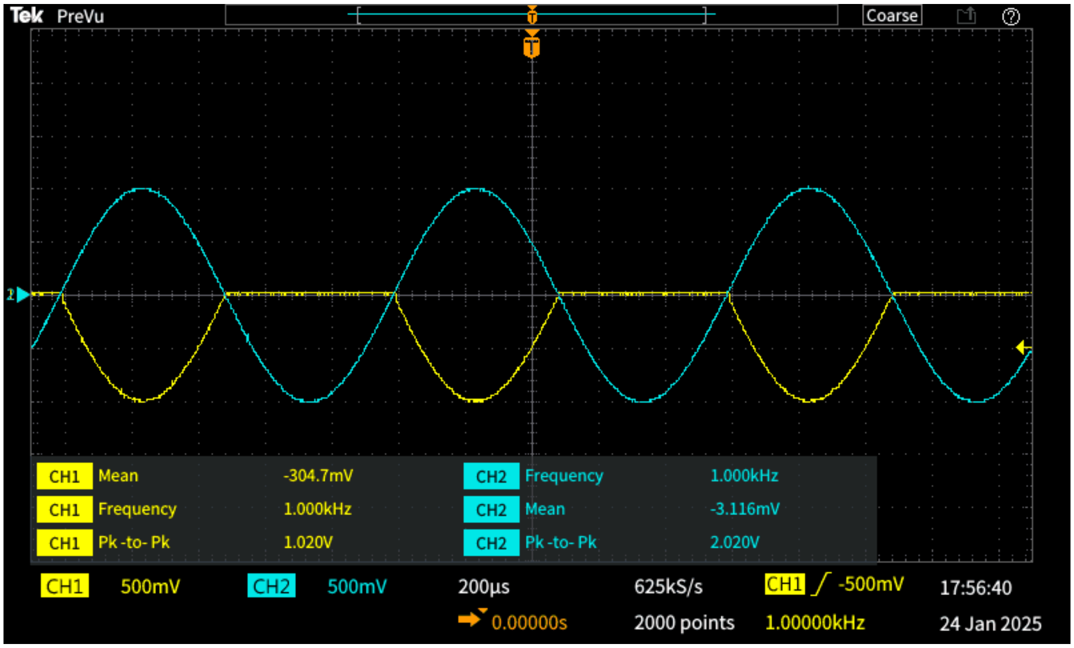


Figure 5: Output of Half-Wave inverting rectifier and $V_{in}$

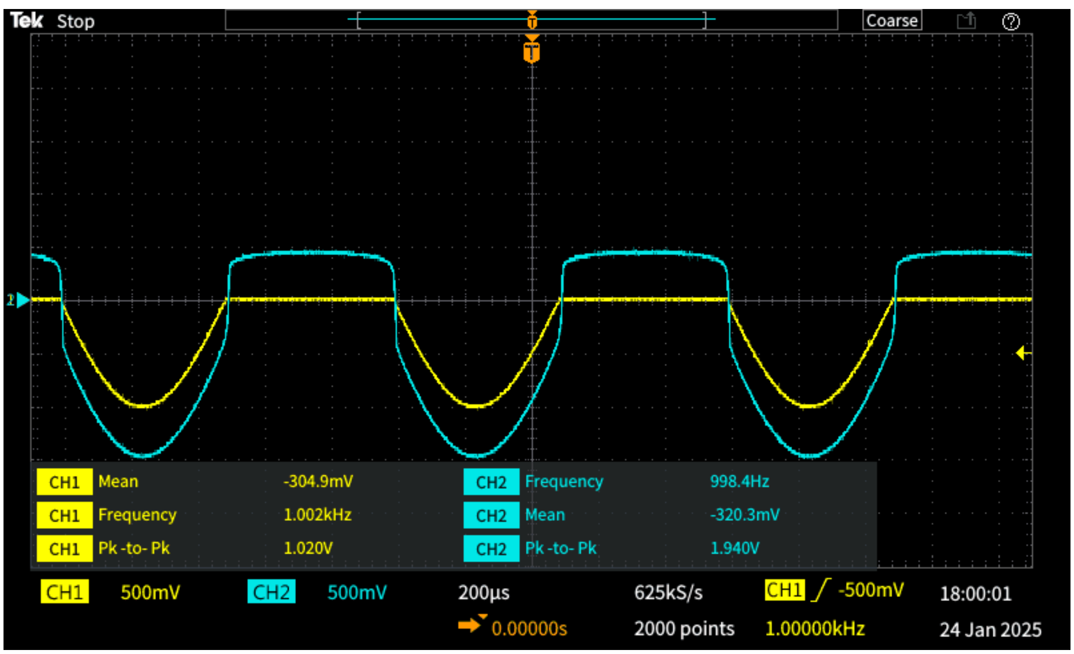


Figure 6: $V_o'$ and $V_{in}$ waveform

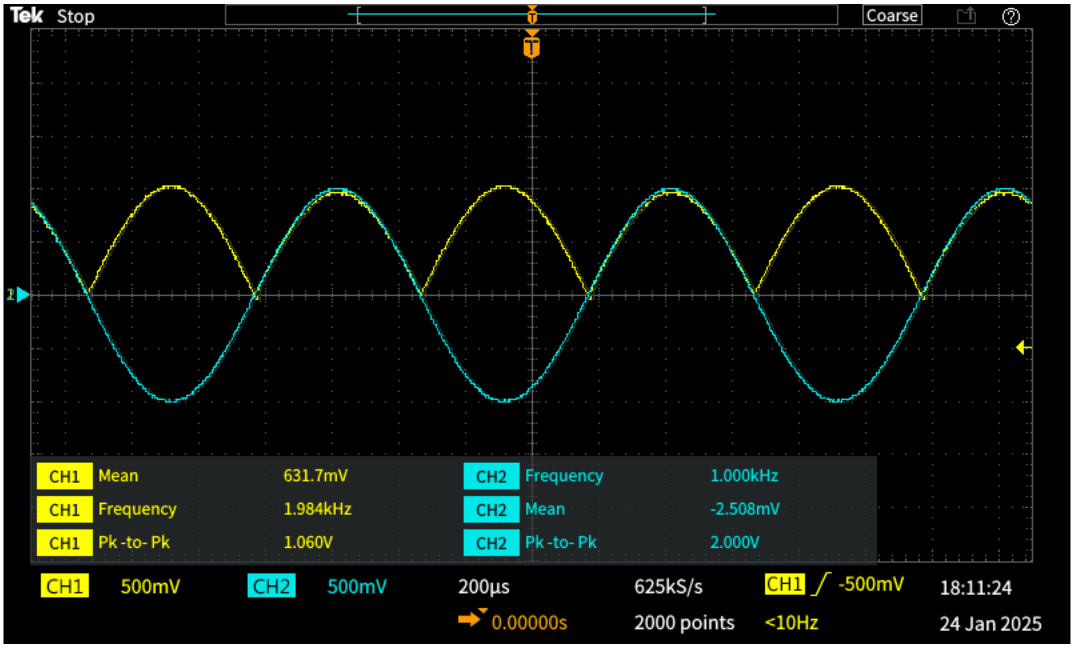


Figure 7: Output of Full-Wave rectifier and $V_{in}$ waveform

## 2.4 Conclusion and Inference

1. The diode drop vanishes because the OpAmp maintains a feedback loop, thus compensating for the voltage drop in diodes.

2. In the center tapped rectifier, the peak output is slightly lower than the input due to the diode forward voltage drop. Whereas in the precision rectifier, the OpAmp compensates for the diode voltage drop, which is exactly equal to the input peak.

# 3 Astable Multivibrator

## 3.1 Aim of the experiment

1. To design and analyze an astable multivibrator circuit that generates continuous square wave signals.
2. To understand the frequency behavior with and without additional circuit components.

## 3.2 Design

The circuit uses a 741 Operational Amplifier powered by a dual supply of ±15V, resistors (R = 47kΩ, $R_1$ = 33kΩ, $R_2$ = 39kΩ), and a capacitor (C = 0.01$\mu$F). Initially, the circuit is implemented without R' = 1kΩ and 4.7V zener diodes. The capacitor voltage ($V_c$) and the output ($V_o$) are observed, and the oscillation frequency is calculated. When R' and the zener diodes are added, the output voltage swing is limited, and waveform behavior changes. Shorting R' theoretically causes instability due to high current flow through the diodes.

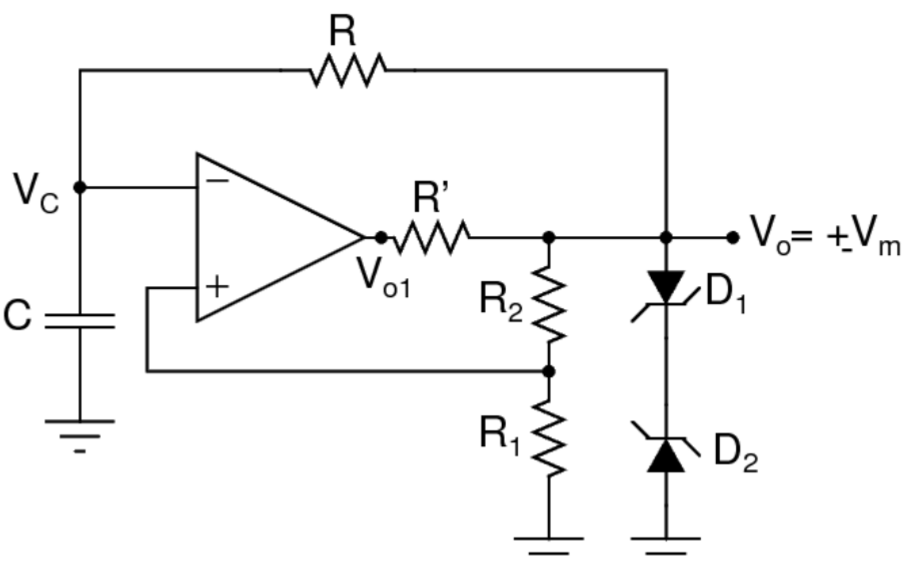


Figure 8: Astable Multivibrator

## 3.3 Experimental results

| Sr. No. | Parameter | Value |
|---|---|---|
| 1 | $V_o$ frequency (Half-Wave Rectifier) | 865 Hz |
| 2 | $V_o$ frequency (Full-Wave Rectifier) | 1836 Hz |
| 3 | $V_{o1}$ | 26.20 $V_{PP}$ |
| 4 | $V_o$ | 11.40 $V_{PP}$ |

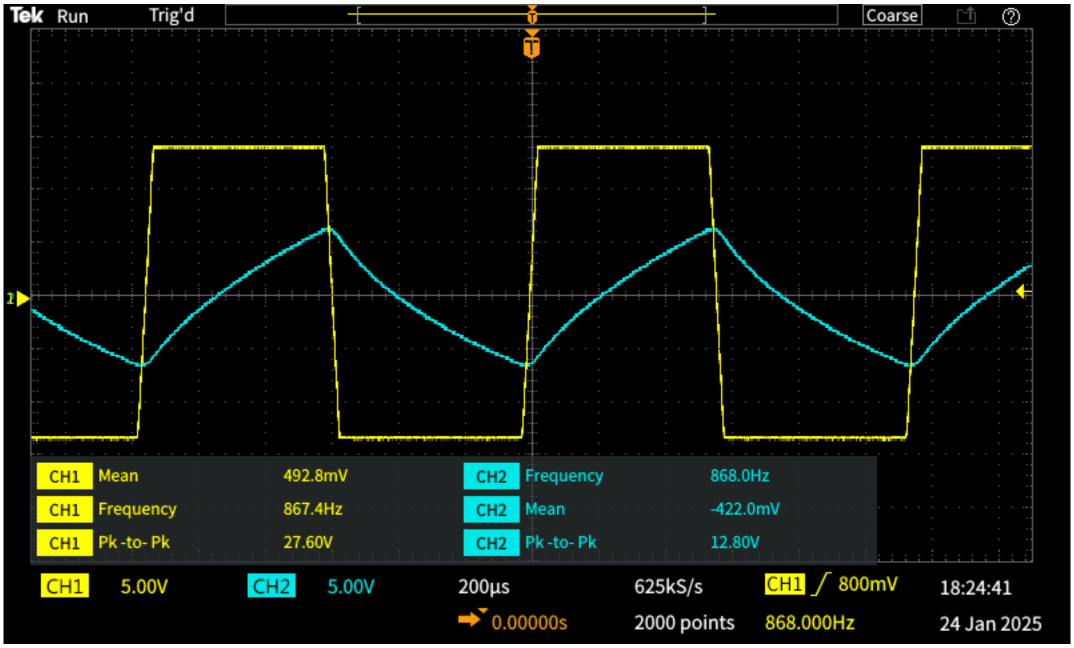


Figure 9: $V_c$ and $V_o$ waveforms

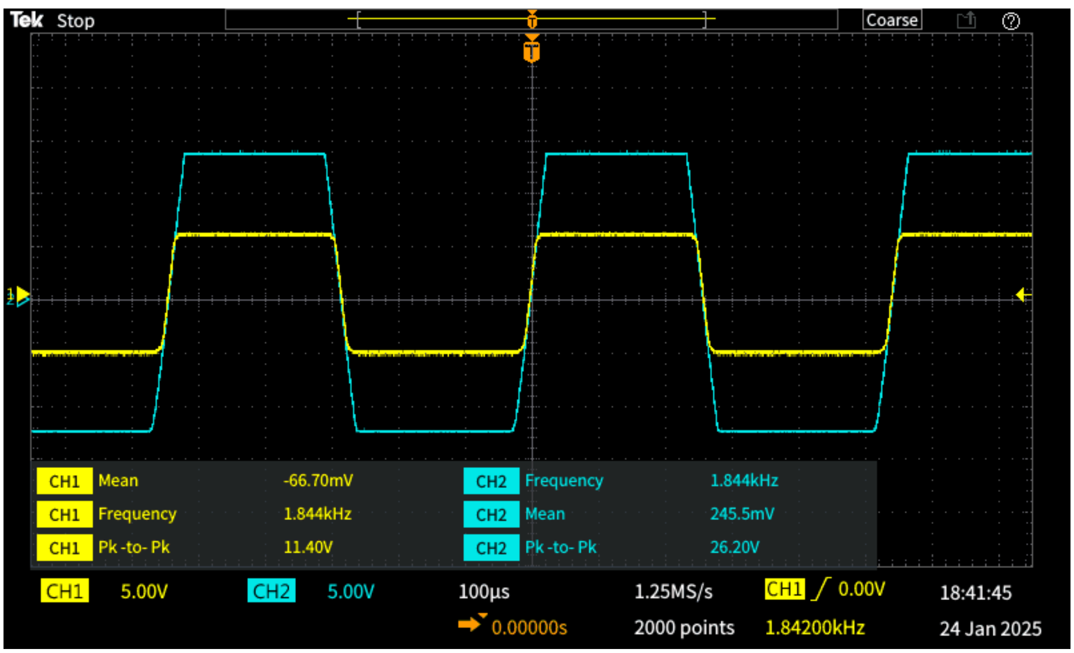


Figure 10: $V_{o1}$ and $V_o$ waveforms

### 3.4 Conclusion and Inference

1. We can't replace R' with a short while keeping diodes in the circuit because if we do so, then a large current will flow through the diodes and damage them.

# 4 Monostable Multivibrator

## 4.1 Aim of the experiment

1. To design and analyze a monostable multivibrator circuit using an operational amplifier.
2. To study the output pulse width and stability of the circuit.

## 4.2 Design

The circuit uses a 741 operational amplifier, a ±15V dual supply, 4.7V zener diodes, a 10$\mu$F capacitor, and resistors ($R_1$ = 10k$\Omega$, $R_2$ = 10k$\Omega$, $R'$ = 1k$\Omega$). The circuit has one stable state, and a momentary shorting of the capacitor triggers the unstable state, generating a single pulse at $V_o$. The pulse width is determined by the RC time constant and is calculated and compared with the measured value. The circuit transitions back to the stable state after the pulse duration.

$$\text{Pulse Width (w)} = RCln(\frac{V_{sat} + V_{th}}{V_{sat} - V_{th}}) \tag{2}$$

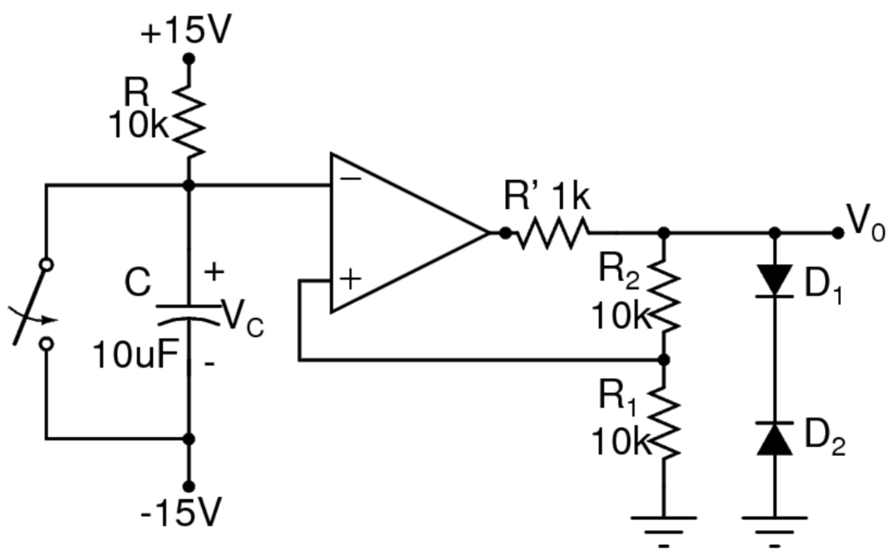


Figure 11: Monostable Multivibrator

## 4.3 Experimental results

| Sr. No. | Parameter | Value |
|---|---|---|
| 1 | Pulse Width (measured) | 197 ms |
| 2 | Pulse Width (calculated) | 116 ms |
| 3 | $V_{sat}$ | 4 V |
| 4 | $V_{th}$ | 2.1 V |

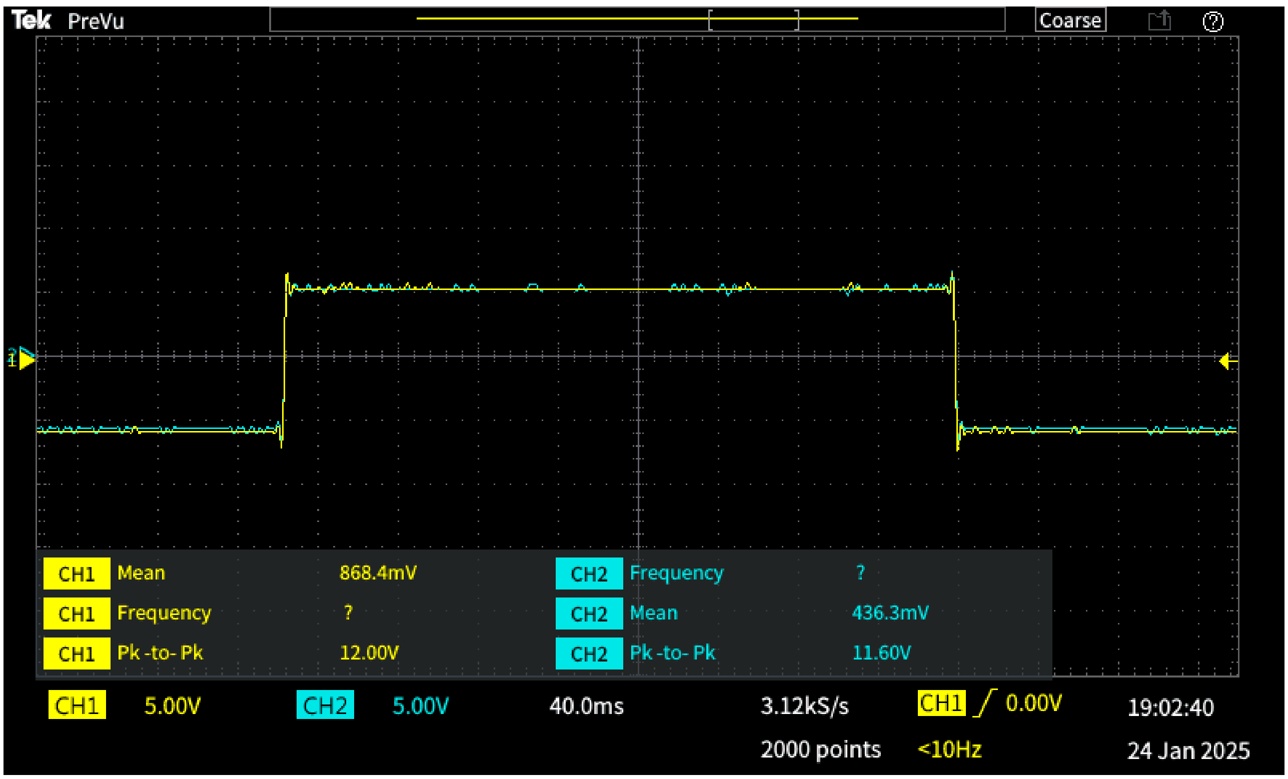


Figure 12: Pulse Waveform

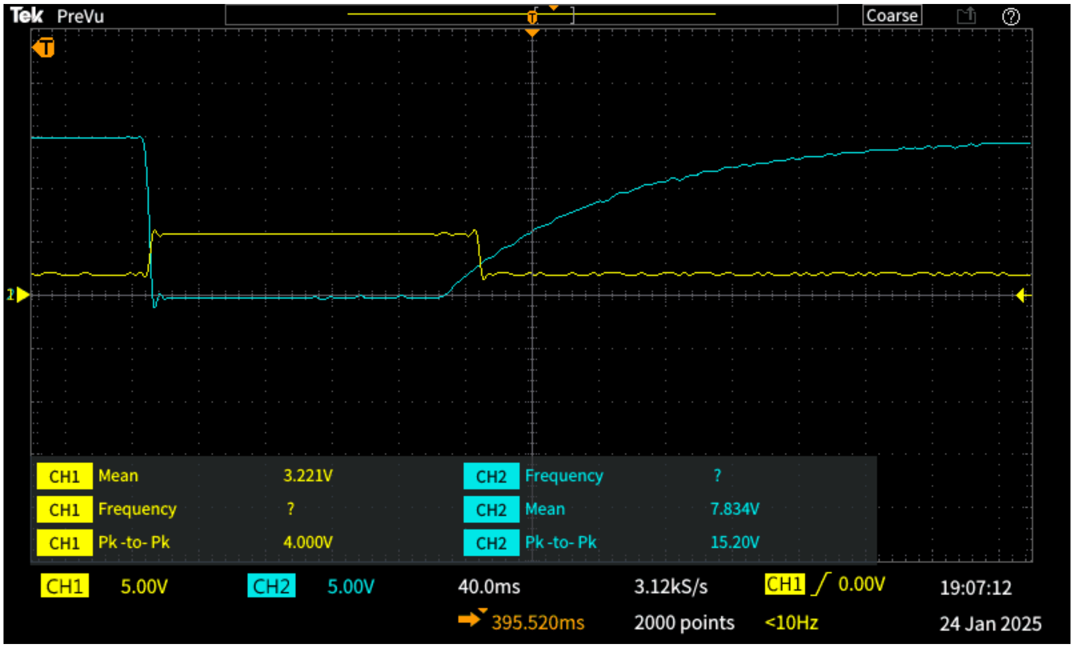


Figure 13: Pulse and $V_C$ Waveforms

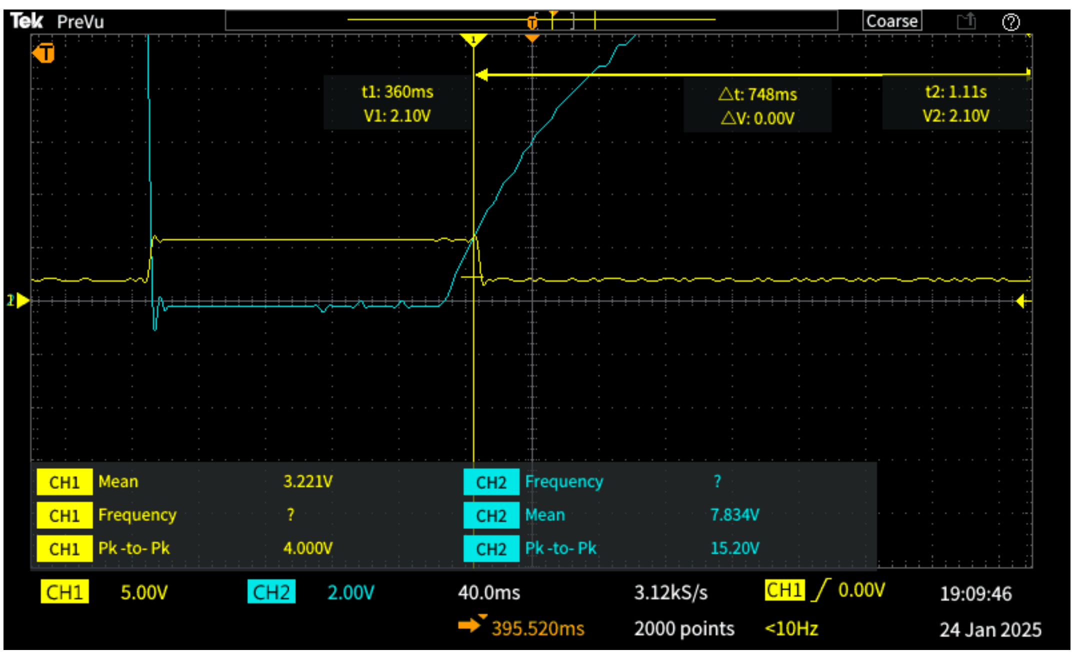


Figure 14: Measuring the $V_{th}$

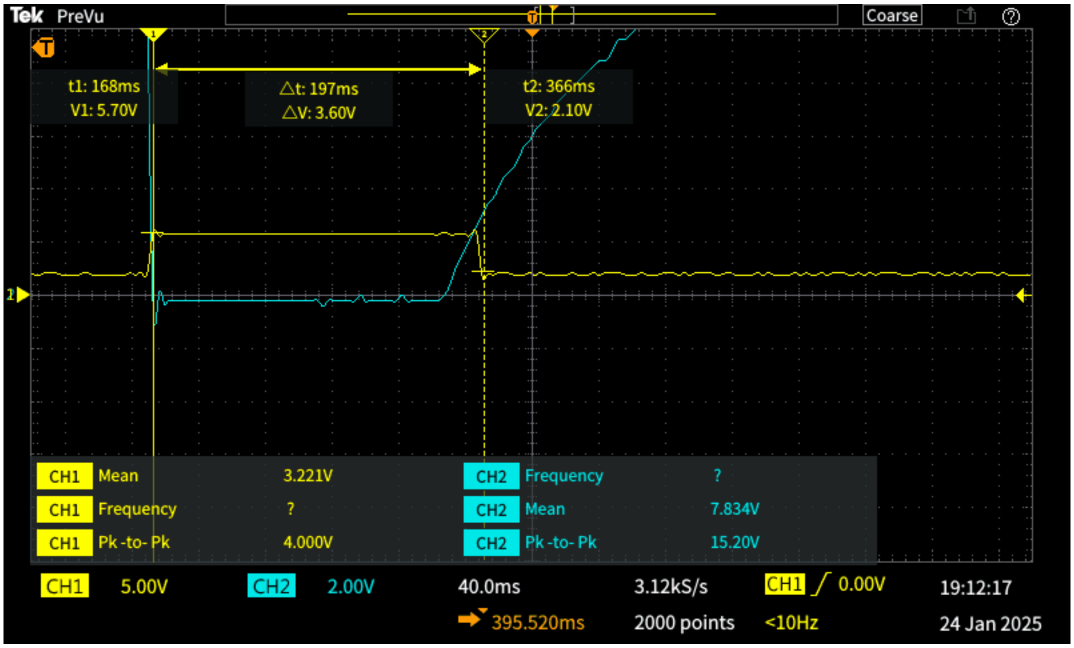


Figure 15: Measuring the Pulse Width

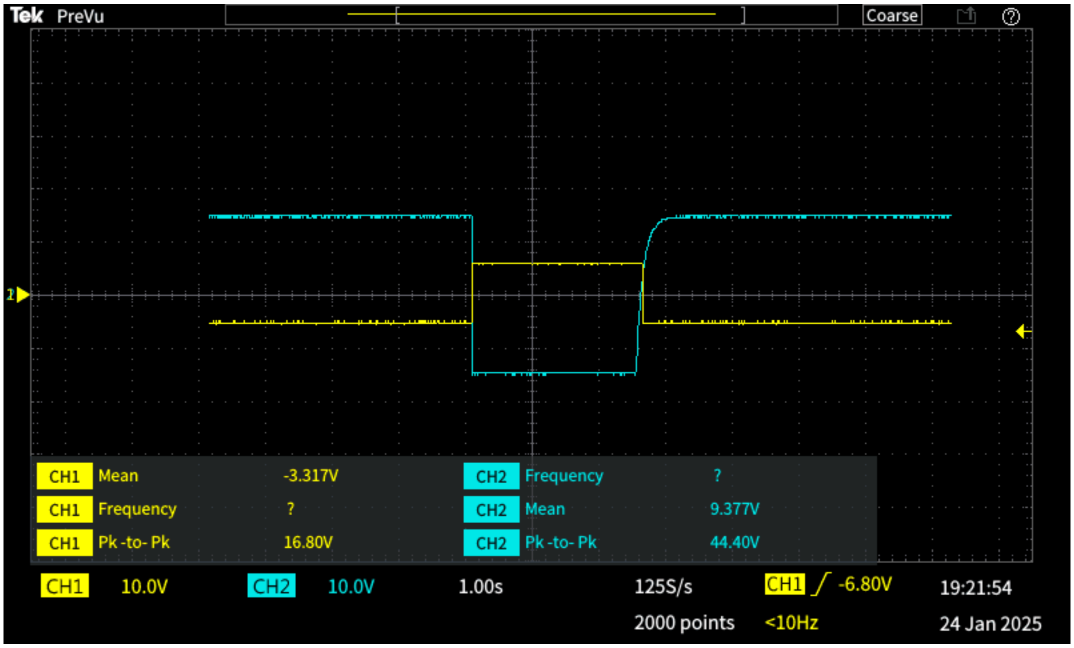


Figure 16: $V_-$ and $V_o$ Waveforms

### 4.4 Conclusion and Inference

1. The objective of short-circuiting the capacitor is to generate a pulse in the circuit.

2. The circuit is Monostable i.e. it has one stable state. But the possible number of states the circuit can take is 2 being 0V and 4V.

## 5 Experiment completion status

The complete experiment was performed in front of the TA in the lab itself.