# EE 236: Experiment 3
# Photodiode Characteristics and Applications

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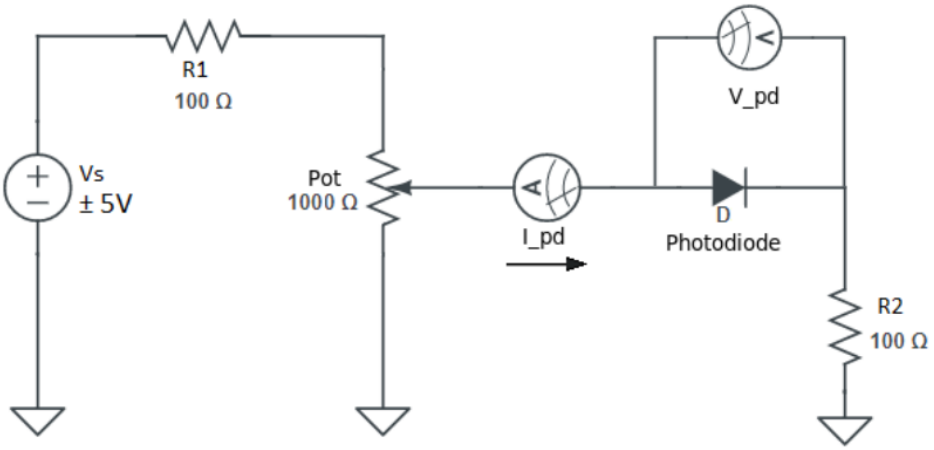
## 1 Aim

- To study the forward and reverse bias I/V characteristics of a Photodiode.
- To measure the response of the Photodiode for different lights and different intensities. (4 LEDs are provided, along with their current vs intensity data)
- To use the Photodiode as an optical signal sensor in combination with an Infra-red LED.

## 2 Parts of the Experiment

### 2.1 Part 1

#### 2.1.1 Circuit

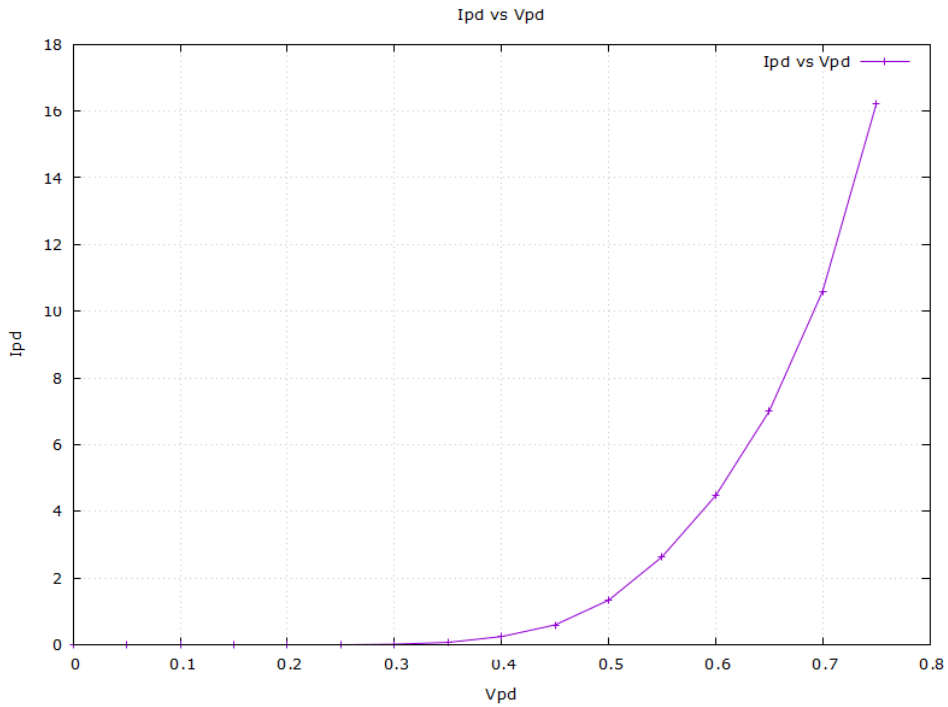


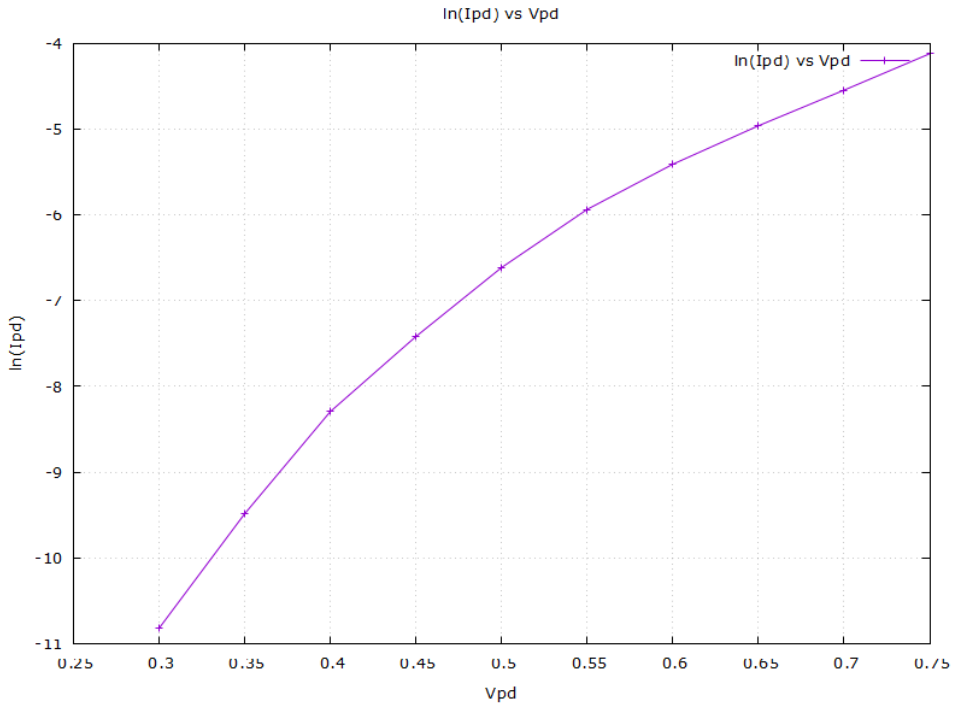
### 2.1.2 I-V data

| V_pd | I_pd (mA) | ln(abs(I_pd)) |
|---|---|---|
| 0 | 0 | |
| 0.05 | 0 | |
| 0.1 | 0 | |
| 0.15 | 0 | |
| 0.2 | 0 | |
| 0.26 | 0 | |
| 0.46 | 0.65 | -7.3385 |
| 0.543 | 1.98 | -6.2247 |
| 0.567 | 2.83 | -5.8675 |
| 0.572 | 3 | -5.8091 |
| 0.578 | 3.22 | -5.7384 |
| 0.588 | 3.58 | -5.6324 |
| 0.592 | 3.74 | -5.5887 |
| 0.603 | 4.16 | -5.4822 |
| 0.62 | 4.89 | -5.3206 |
| 0.63 | 5.44 | -5.2140 |
| 0.653 | 6.66 | -5.0116 |
| 0.672 | 7.89 | -4.8422 |
| 0.708 | 10.88 | -4.5208 |
| 0.759 | 16.77 | -4.0882 |
| 0.766 | 17.91 | -4.0224 |

- **Ideality factor** : 3.7531

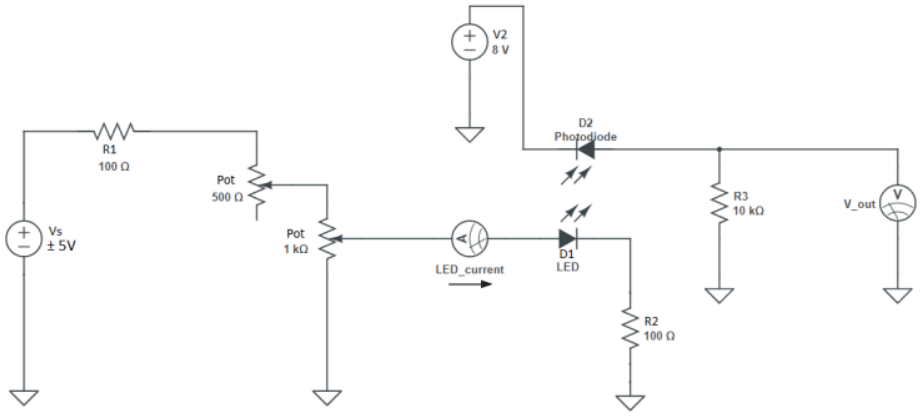
### 2.1.3 Plots






## 2.2 Part 2

### 2.2.1 Circuit



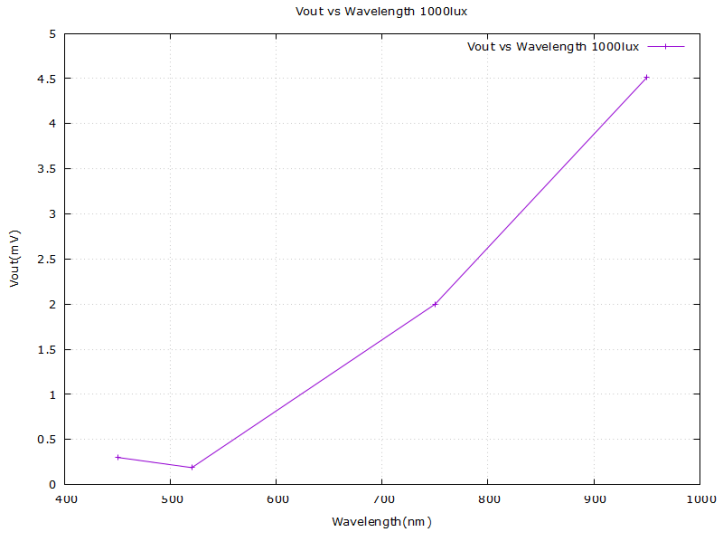

### 2.2.2 Data

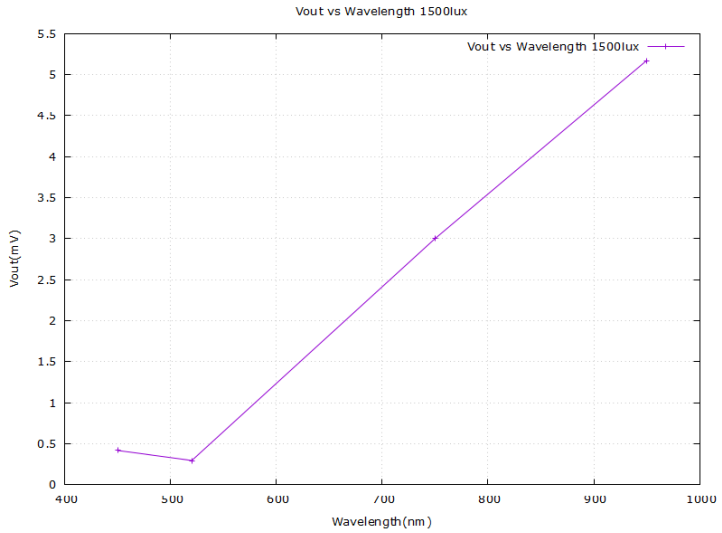
| | Vout(V) | | | |
|---|---|---|---|---|
| **Intensity(lux)** | **IR** | **Red** | **Green** | **Blue** |
| 1000 | 4.51E-03 | 2.00E-03 | 1.88E-04 | 3.01E-04 |
| 1500 | 5.17E-03 | 3.00E-03 | 2.94E-04 | 4.16E-04 |
| 2000 | 6.28E-03 | 4.00E-03 | 3.71E-04 | 5.72E-04 |

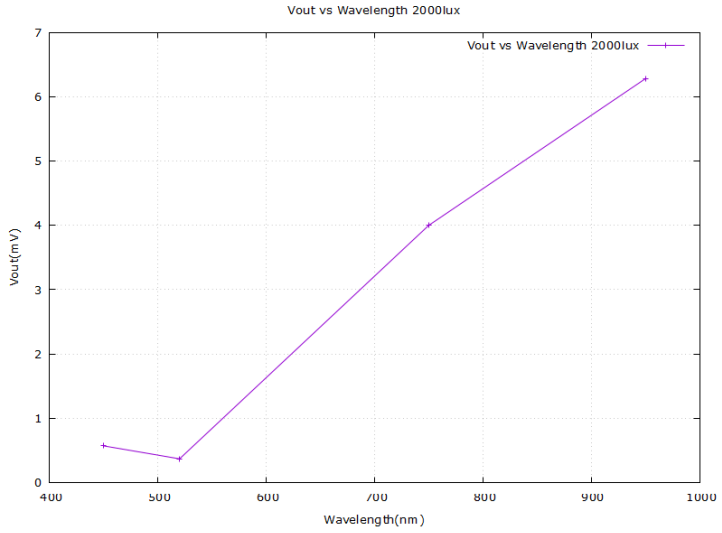
| | **IR** | **Red** | **Green** | **Blue** |
|---|---|---|---|---|
| **Lambda (m)** | 9.50E-07 | 7.50E-07 | 5.20E-07 | 4.50E-07 |

### 2.2.3 Plots

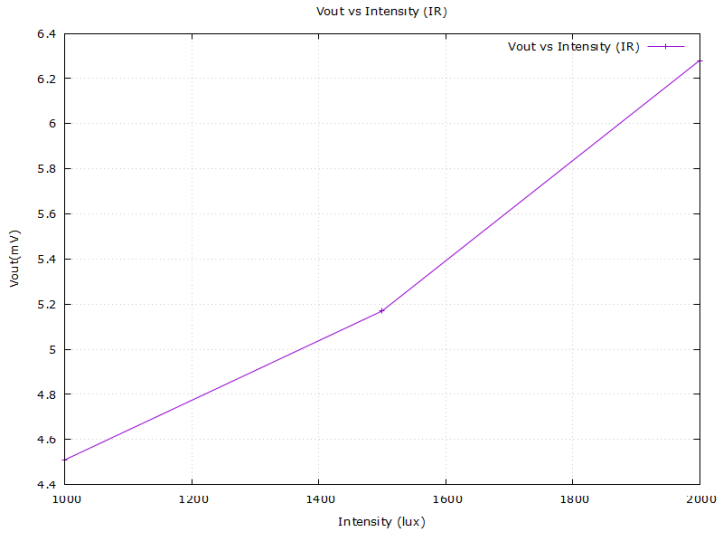
### 2.2.4 Vout vs Wavelength

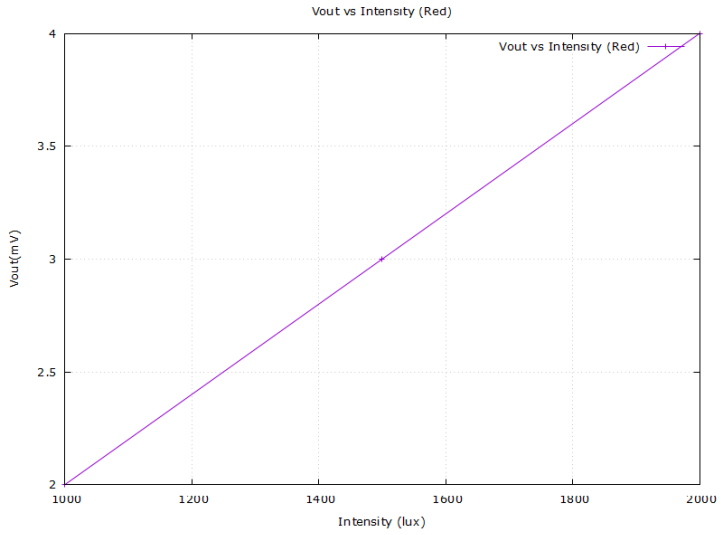


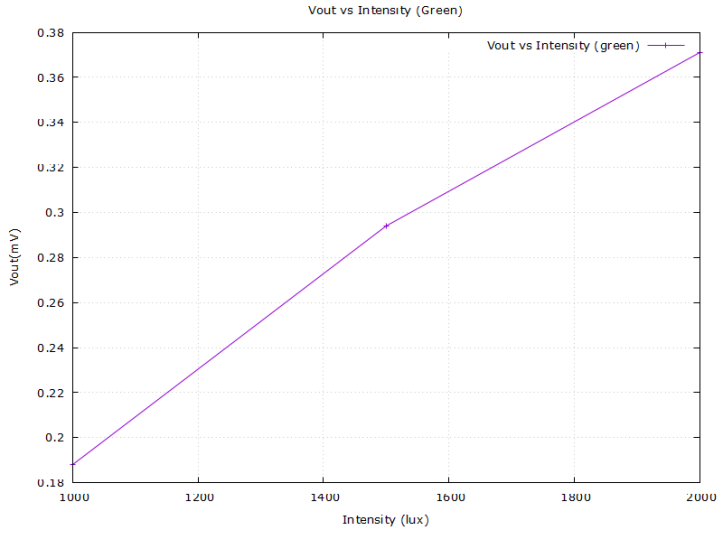



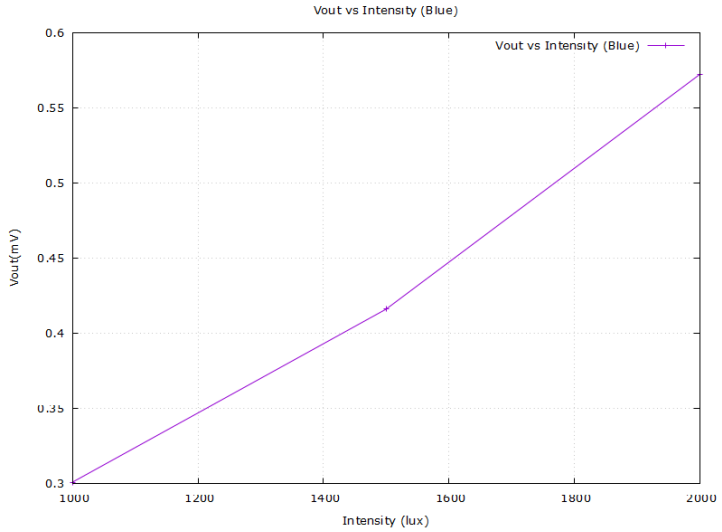



### 2.2.5 Vout vs Intensity



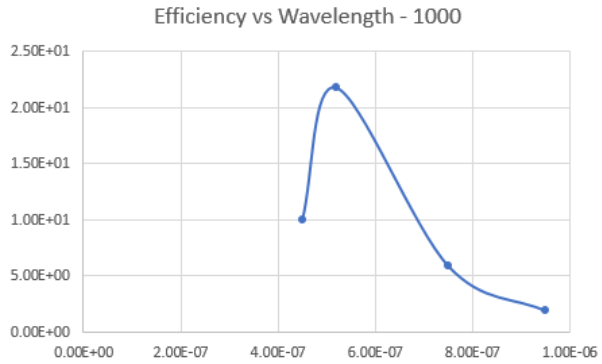


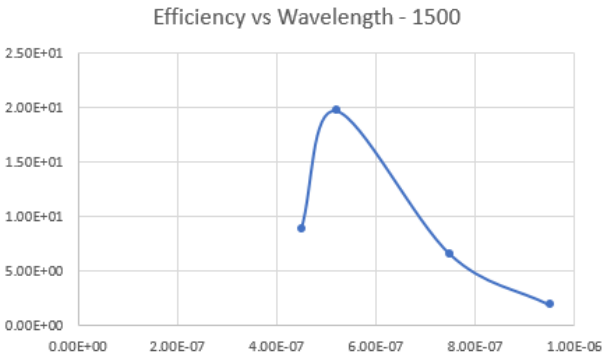



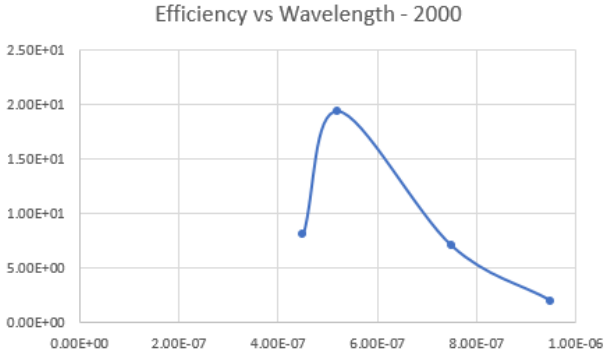

### 2.2.6 Efficiency

| Intensity | IR/Intensity | Red/Intensity | Green/Intensity | Blue/Intensity |
|---|---|---|---|---|
| 1000 | 1.91E-03 | 5.90E-03 | 2.18E-02 | 9.97E-03 |
| 1500 | 1.27E-03 | 4.35E-03 | 1.31E-02 | 5.93E-03 |
| 2000 | 9.85E-04 | 3.50E-03 | 9.70E-03 | 4.02E-03 |
| Lambda | 9.50E-07 | 7.50E-07 | 5.20E-07 | 4.50E-07 |

Most efficient: Green

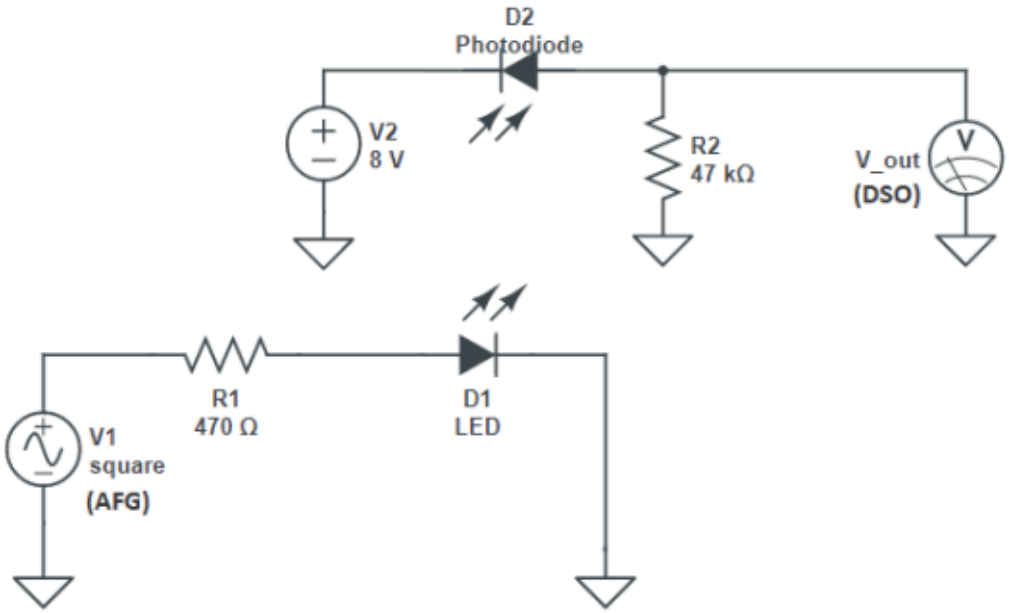

Efficiency vs Wavelength - 1000
2.50E+01
2.00E+01
1.50E+01
1.00E+01
5.00E+00
0.00E+00
0.00E+00
2.00E-07
4.00E-07
6.00E-07
8.00E-07
1.00E-06


Efficiency vs Wavelength - 1500
2.50E+01
2.00E+01
1.50E+01
1.00E+01
5.00E+00
0.00E+00
0.00E+00
2.00E-07
4.00E-07
6.00E-07
8.00E-07
1.00E-06


Efficiency vs Wavelength - 2000
2.50E+01
2.00E+01
1.50E+01
1.00E+01
5.00E+00
0.00E+00
0.00E+00
2.00E-07
4.00E-07
6.00E-07
8.00E-07
1.00E-06

## 2.3 Part 3

### 2.3.1 Circuit



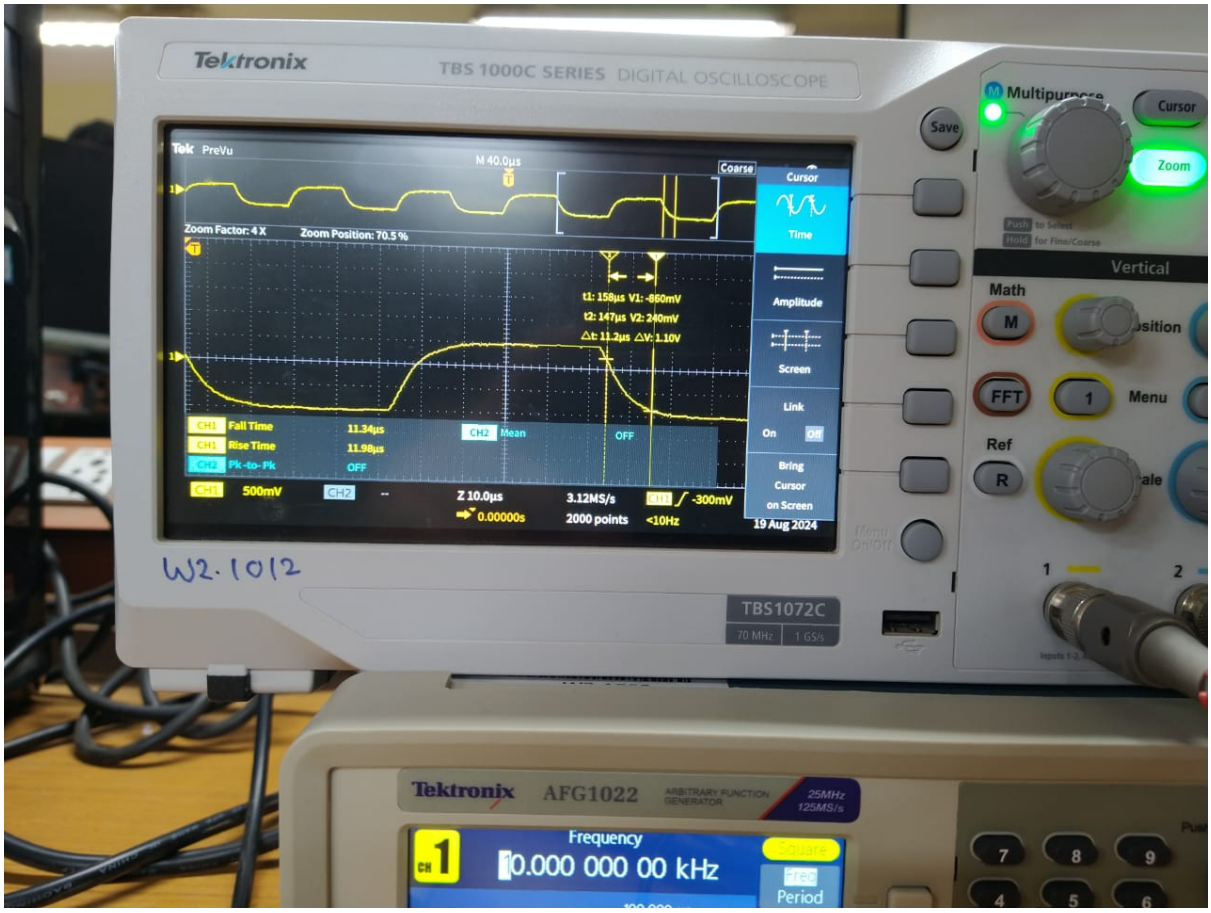

### 2.3.2 Data

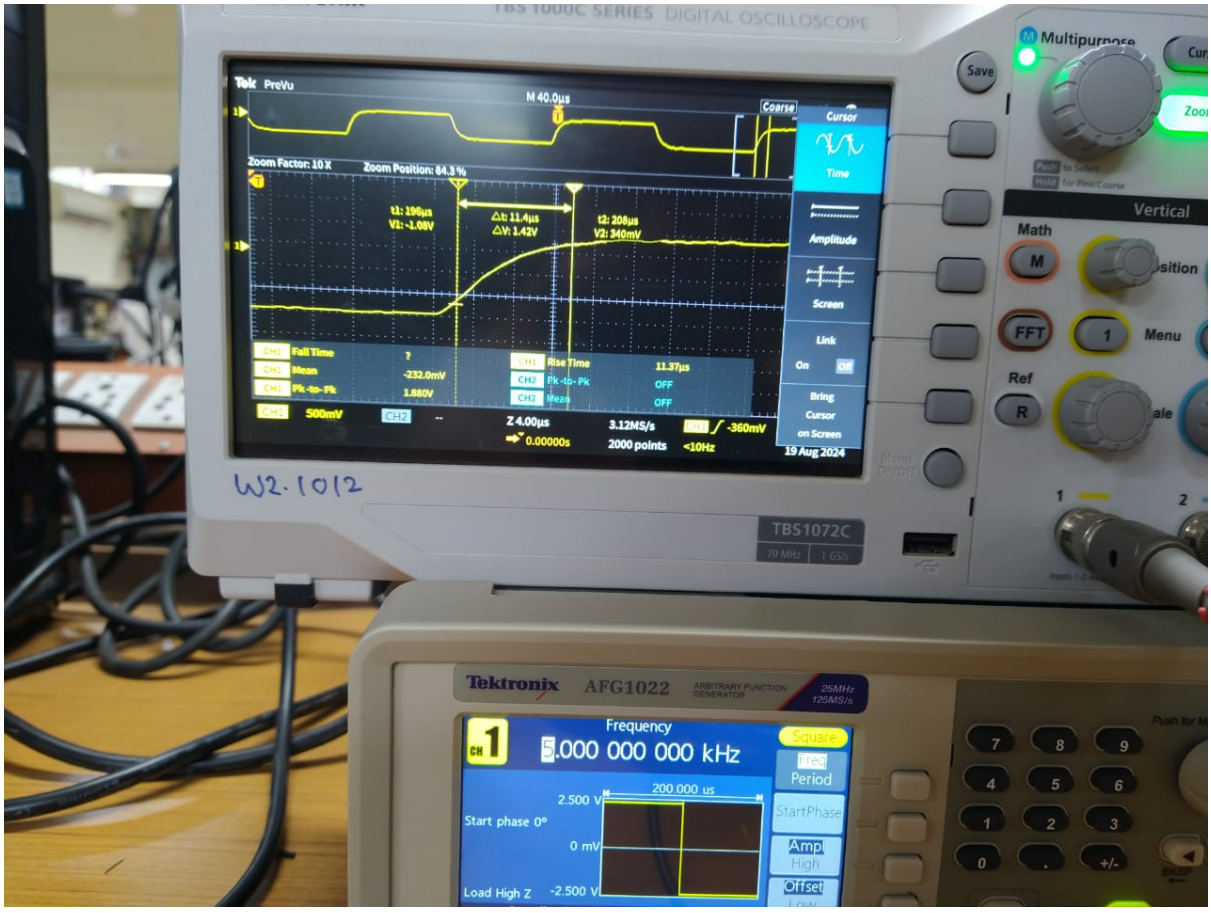
| Frequency (Hz) | Rise time (us) | Fall time (us) |
|---|---|---|
| 1000 | 15.37 | 15.72 |
| 5000 | 11.37 | 11.62 |
| 10000 | 11.98 | 11.34 |
| 15000 | 12.31 | 12.15 |
| 20000 | 12.19 | 12.03 |

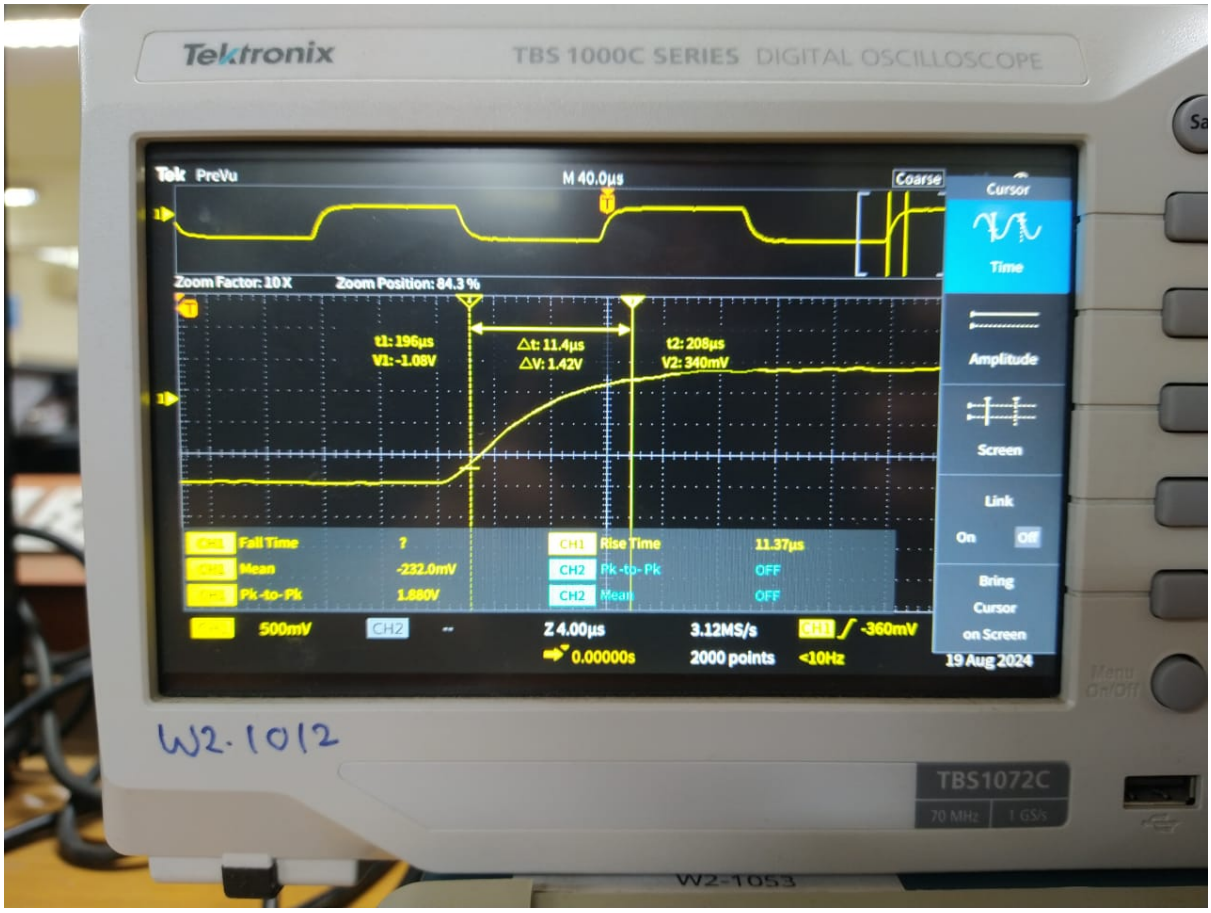
### 2.3.3 Observations and Reasoning

- **Distortion:** Distortion is observed to become too large at 20 kHz.
- **Reason for Slow Photodiode Response:** A photodiode has a "detection bandwidth" associated with it, which determines the speed at which its output can vary in response to a varying input signal. This bandwidth depends on two factors:
  1. Junction capacitance in the diode.
  2. Transit time of the photocurrent in the junction.

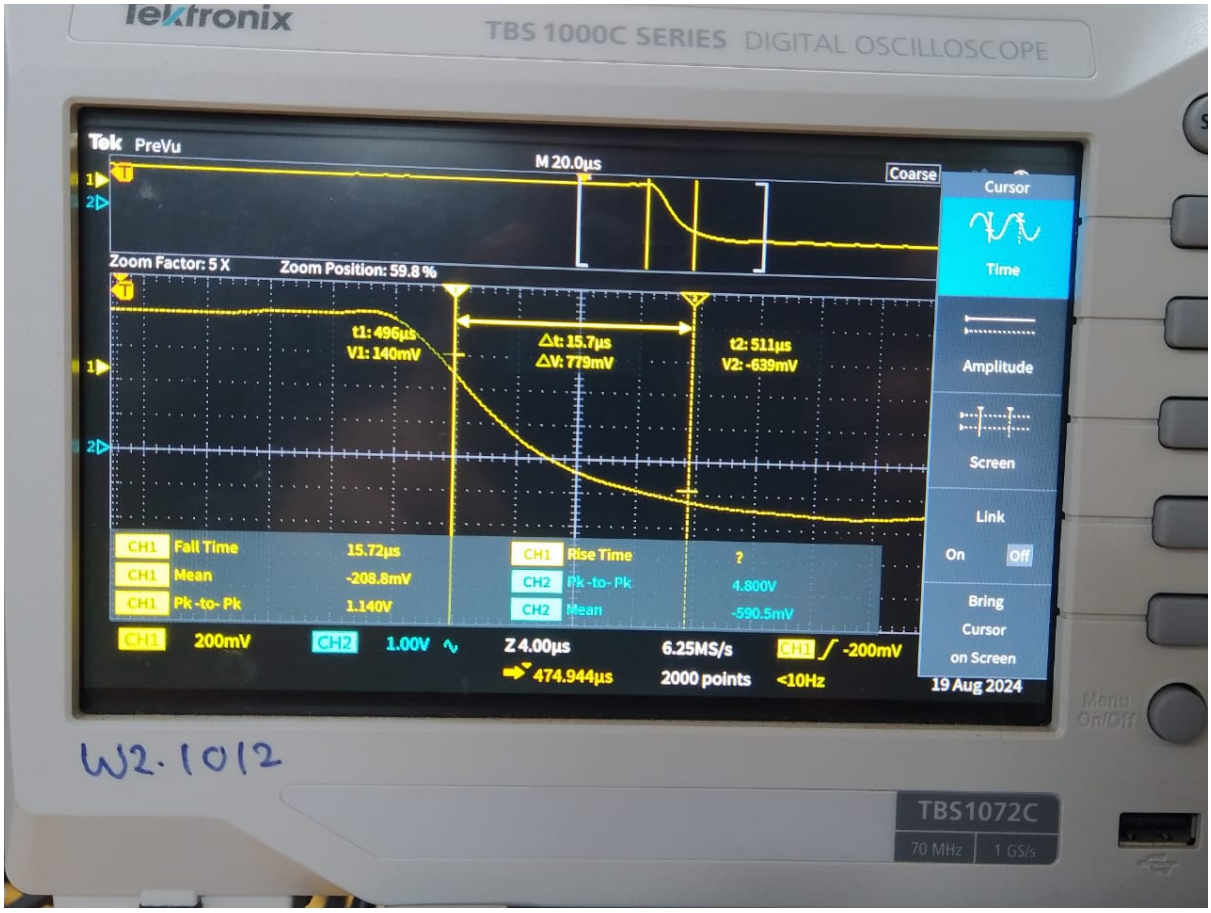
## 2.4 Observation Pictures Taken in LAB DSO

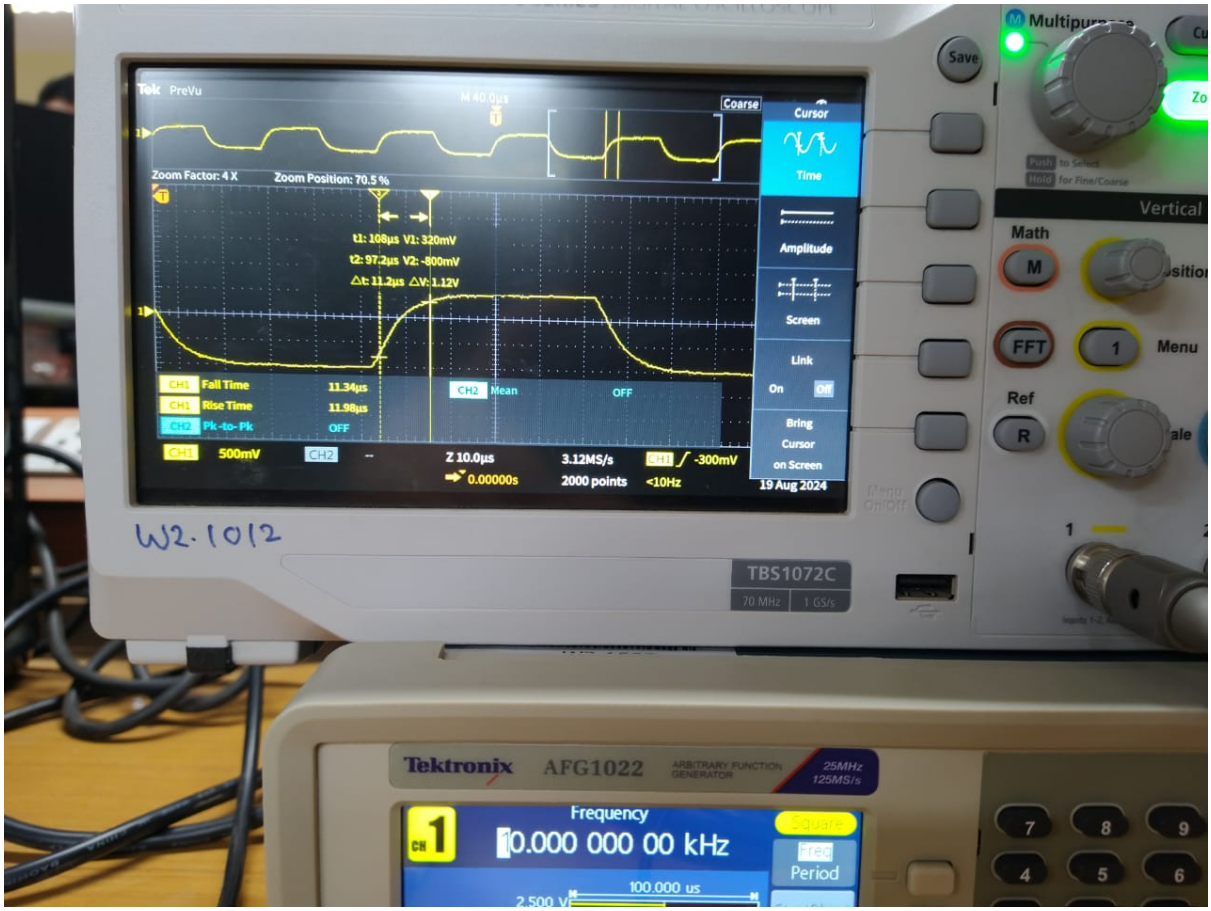

Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Tek PreVu
M 40.0µs
Coarse
Zoom Factor: 4 X
Zoom Position: 70.5 %
t1: 158µs V1: -860mV
t2: 147µs V2: 240mV
Δt: 11.2µs ΔV: 1.10V
CH1 Fall Time 11.34µs
CH1 Rise Time 11.98µs
CH2 Pk-to-Pk OFF
CH2 Mean OFF
CH1 500mV CH2 -- Z 10.0µs 3.12MS/s -300mV
0.00000s 2000 points <10Hz 19 Aug 2024
Cursor
Time
Amplitude
Screen
Link On Off
Bring Cursor on Screen
Save
Multipurpose
Cursor
Zoom
Vertical
Math
M
FFT
1
Menu
Ref
R
W2.1012
TBS1072C
70 MHz 1 GS/s
Tektronix AFG1022
ARBITRARY FUNCTION GENERATOR
25MHz 125MS/s
CH 1
Frequency
10.000 000 00 kHz
Square
Period

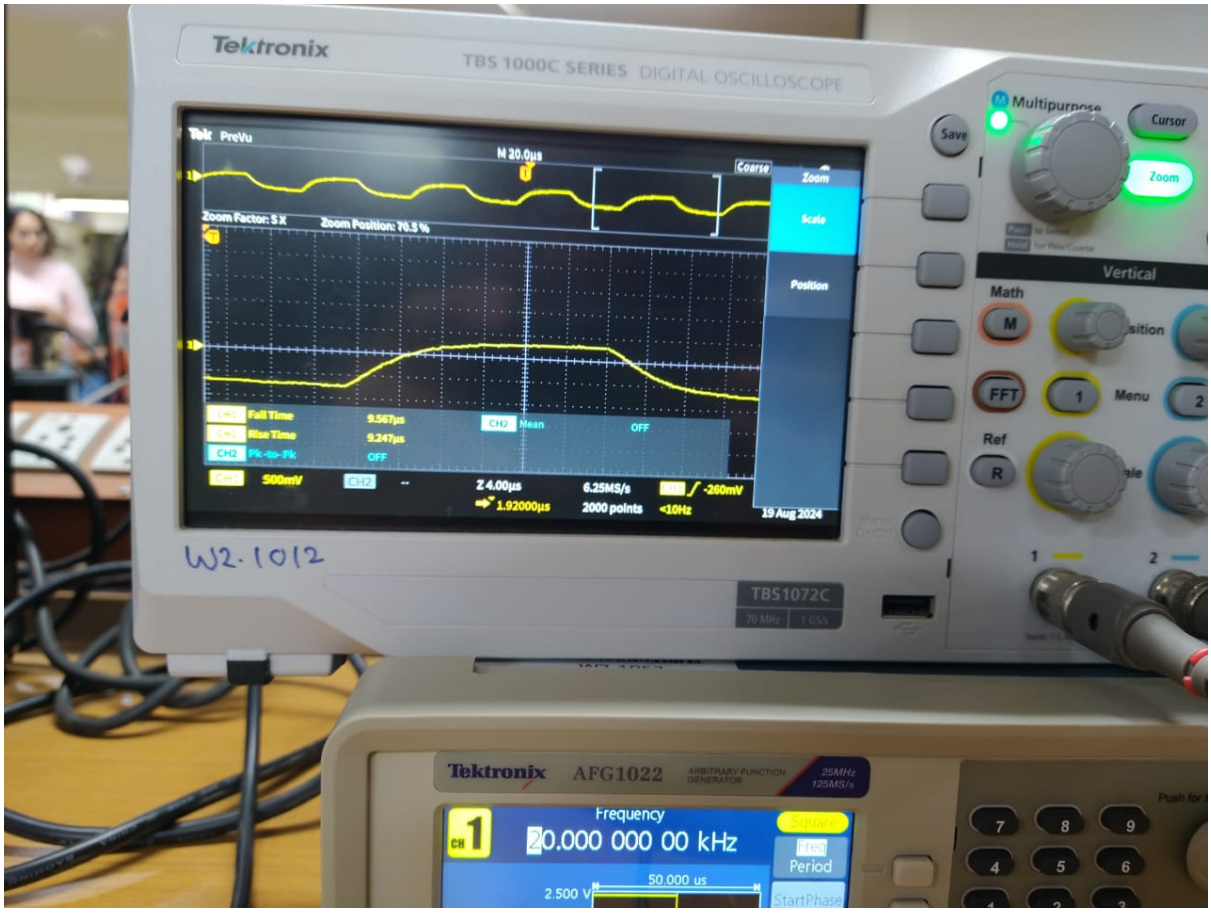

Tek PreVu
M 40.0µs
Coarse
Zoom Factor: 10 X
Zoom Position: 84.3 %
t1: 196µs V1: -1.08V
Δt: 11.4µs ΔV: 1.42V
t2: 208µs V2: 340mV
CH1 Fall Time ?
CH1 Mean -232.0mV
CH1 Pk-to-Pk 1.880V
CH1 Rise Time 11.37µs
CH2 Pk-to-Pk OFF
CH2 Mean OFF
CH1 500mV CH2 -- Z 4.00µs 3.12MS/s -360mV
0.00000s 2000 points <10Hz 19 Aug 2024
W2.1012
TBS1072C
Tektronix AFG1022
CH 1
Frequency
5.000 000 000 kHz
Square
Period
200.000 us
2.500 V
Start phase 0°
0 mV
Load High Z
-2.500 V
StartPhase
Amp
High
Offset

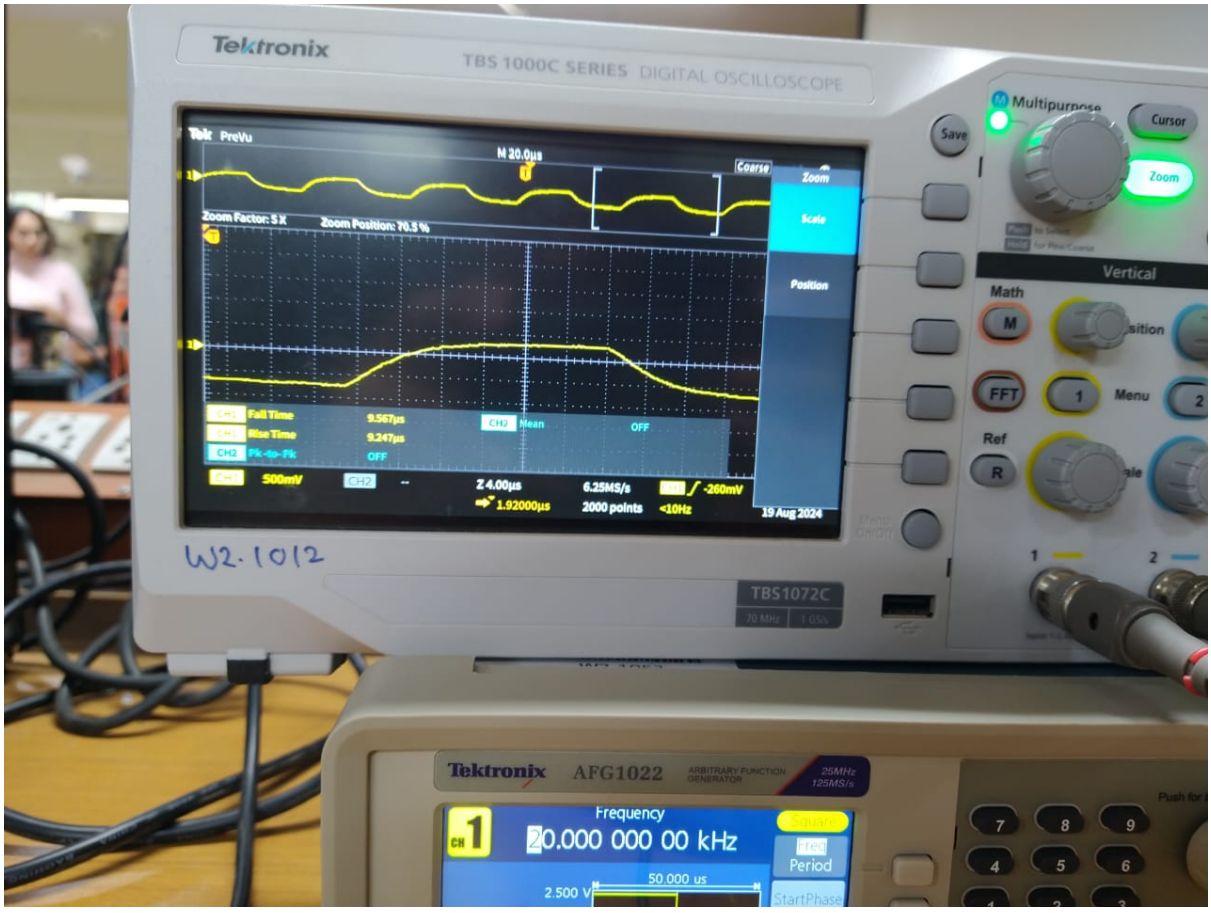

Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Tek PreVu
M 40.0µs
Coarse
Zoom Factor: 10 X
Zoom Position: 84.3 %
t1: 196µs
V1: -1.08V
Δt: 11.4µs
ΔV: 1.42V
t2: 208µs
V2: 340mV
Fall Time ?
Mean -232.0mV
Pk-to-Pk 1.880V
Rise Time 11.37µs
Pk-to-Pk OFF
Mean OFF
500mV
Z 4.00µs
3.12MS/s
-360mV
0.00000s
2000 points
<10Hz
19 Aug 2024
Cursor
Time
Amplitude
Screen
Link
On Off
Bring Cursor on Screen
W2.1012
TBS1072C
70 MHz 1 GS/s
W2-1053


Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Save
Tek PreVu
M 20.0µs
Coarse
Zoom Factor: 5 X
Zoom Position: 59.8 %
t1: 10.5µs V1: 220mV
t2: -4.88µs V2: -779mV
Δt: 15.4µs ΔV: 1.00V
Mean -180.0mV
Pk-to-Pk 1.140V
Rise Time 15.37µs
Pk-to-Pk OFF
Frequency OFF
Mean OFF
200mV
Z 4.00µs
6.25MS/s
-216mV
-23.9360µs
2000 points
<10Hz
19 Aug 2024
Cursor
Time
Amplitude
Screen
Link
On Off
Bring Cursor on Screen
W2.1012
TBS1072C
70 MHz 1 GS/s


Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Tek PreVu
M 20.0µs
Coarse
Zoom Factor: 5 X
Zoom Position: 59.8 %
t1: 496µs
V1: 140mV
Δt: 15.7µs
ΔV: 779mV
t2: 511µs
V2: -639mV
CH1 Fall Time 15.72µs
CH1 Mean -208.8mV
CH1 Pk-to-Pk 1.140V
CH1 Rise Time ?
CH2 Pk-to-Pk 4.800V
CH2 Mean -590.5mV
CH1 200mV
CH2 1.00V
Z 4.00µs
474.944µs
6.25MS/s
2000 points
CH1 -200mV
<10Hz
19 Aug 2024
Cursor
Time
Amplitude
Screen
Link
On Off
Bring Cursor on Screen
W2.1012
TBS1072C
70 MHz 1 GS/s


Tek PreVu
Coarse
Zoom Factor: 4 X
Zoom Position: 70.5 %
t1: 108µs V1: 320mV
t2: 97.2µs V2: -800mV
Δt: 11.2µs ΔV: 1.12V
CH1 Fall Time 11.34µs
CH1 Rise Time 11.98µs
CH2 Pk-to-Pk OFF
CH2 Mean OFF
CH1 500mV
Z 10.0µs
0.00000s
3.12MS/s
2000 points
CH1 -300mV
<10Hz
19 Aug 2024
Cursor
Time
Amplitude
Screen
Link
On Off
Bring Cursor on Screen
Save
Vertical
Math
M
FFT
1
Menu
Ref
R
W2.1012
TBS1072C
70 MHz 1 GS/s
Tektronix AFG1022
ARBITRARY FUNCTION GENERATOR
25MHz 125MS/s
Frequency
10.000 000 00 kHz
Square
Freq
Period
100.000 us


Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Multipurpose
Cursor
Zoom
Save
Vertical
Math
FFT
Menu
Ref
Tek PreVu
M 20.0µs
Coarse
Zoom Factor: 5 X
Zoom Position: 70.3 %
Scale
Position
Fall Time 9.567µs
Rise Time 9.247µs
Pk-to-Pk OFF
CH2 Mean OFF
500mV
CH2
Z 4.00µs
1.92000µs
6.25MS/s
2000 points
-260mV
<10Hz
19 Aug 2024
W2.1012
TBS1072C
70 MHz 1 GS/s
Tektronix AFG1022
ARBITRARY FUNCTION GENERATOR
25MHz 125MS/s
Frequency
20.000 000 00 kHz
Square
Period
50.000 us
2.500 V
StartPhase


Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Multipurpose
Cursor
Zoom
Save
Vertical
Math
FFT
Menu
Ref
Tek PreVu
M 20.0µs
Coarse
Zoom Factor: 5 X
Zoom Position: 70.3 %
Scale
Position
Fall Time 9.567µs
Rise Time 9.247µs
Pk-to-Pk OFF
CH2 Mean OFF
500mV
CH2
Z 4.00µs
1.92000µs
6.25MS/s
2000 points
-260mV
<10Hz
19 Aug 2024
W2.1012
TBS1072C
70 MHz 1 GS/s
Tektronix AFG1022
ARBITRARY FUNCTION GENERATOR
25MHz 125MS/s
Frequency
20.000 000 00 kHz
Square
Period
50.000 us
2.500 V
StartPhase


Tek PreVu
M 20.0µs
Coarse
Zoom Factor: 5 X
Zoom Position: 70.5 %
Fall Time 12.15µs
Rise Time 12.31µs
Pk-to-Pk OFF
Mean OFF
500mV
Z 4.00µs
22.5600µs
6.25MS/s
2000 points
-360mV
<10Hz
18:53:06
19 Aug 2024
W2.1012
TBS1072C
70 MHz 1 GS/s
Tektronix AFG1022
Frequency
15.000 000 00 kHz
Square
Save
Math
FFT
Ref
Multipurpose


Tektronix
TBS 1000C SERIES DIGITAL OSCILLOSCOPE
Tek PreVu
M 40.0µs
Coarse
Zoom Factor: 10 X
Zoom Position: 84.3 %
t1: 495µs
V1: 520mV
Δt: 11.4µs
ΔV: 1.56V
t2: 507µs
V2: -1.04V
Fall Time 11.62µs
Mean -275.4mV
Pk-to-Pk 1.860V
Rise Time ?
Pk-to-Pk OFF
Mean OFF
500mV
Z 4.00µs
292.672µs
3.12MS/s
2000 points
-437mV
<10Hz
19 Aug 2024
W2.1012
TBS1072C
Tektronix AFG1022
Frequency
5.000 000 000 kHz
Square
Period
200.000 us
2.500 V
Start phase 0°
0 mV
-2.500 V
Load High Z
Amplitude
5.000 Vpp
Offset
0 mV
Cursor
Time
Amplitude
Screen
Link
Bring Cursor on Screen
Save
Multipurpose
Measure
Zoom
Save Recall
Function
Vertical
Math
FFT
Ref
Menu
Scale
Aux In
Push for Manual Trigger
Inter CH
Utility
Help
Ch1/2
On/Off

# 3 Completion Status

The experiment was thoroughly conducted and successfully completed within the lab setting. All objectives were met, and the procedures were carried out as planned, yielding the expected results.