LAB-02

CSE251

NAME: MALIHA MEHEJABIN

ID: 20301264

SECTION: 07

GROUP: 01

SEMESTER: FALL'22

DATE OF PERFORMANCE: 16/10/22

DATE OF SUBMISSION: 22/10/22

Title: Study to Half-Wave and full wave Diode Rectifier Circuit

Theory: The diode rectifier converts the input sinusoidal voltage V_s to a unipolar output V_o; There are two types of rectifiers circuits (I) Half-wave rectifier
(II) Full-wave rectifier

Half-wave Rectifier:

Where only positive half cycle appears at the output and the negative half is blocked, the AC input voltage changes into a unidirectional DC vt. voltage at the output. and the process of removing half of the input signal to establish a dc level is aptly called half-wave rectification.

HW Rectifier with filter capacitor:

Althoug the rectification stage makes the sine wave voltage to be positive but its result is not flat as DC value. But the capacitor is included to help smooth out the ripples as it wanted.

Peak inverse voltage (PIV):

PIV is the maximum voltage that appears across the diode when it is reverse-biased.

$$PIV = V_m$$

Ripple voltage and Ripple factor:

The output of a rectifier though unidirectional, contains periodically fluctuating components. Value for peak-peak ripple voltage:

$$V_r(p-p) = \frac{V_p}{fCR} = \frac{V_m - V_{D0}}{fCR}$$

Fullwave-Rectifier / Bridge rectifier :

This rectifier utilizes both halves of the input sinusoid. To provide a unipolar output, it inverts the negative halves of the sinewave.

FW Rectifier with capacitor:

The pulsating nature of the output voltage produced by the rectifier circuits discussed above makes it unsuitable as a dc supply for electronics circuits. A capacitor is placed across load resistor to reduce the variation of output voltage.

Ripple voltage and ripple factor:

value of peak to peak ripple voltage,

$$V_r(p-p) = \frac{V_p}{2fCR} = \frac{V_m - 2V_{Do}}{2fCR} \quad [\text{for FW rectifier}]$$

[V_p = peak voltage of output ; f = input frequency ; R = resistance]

ripple factor, $r = \dfrac{\text{rms value of alternating components of the output wave}}{\text{average value of the output wave}}$

$$= \frac{V_{r-rms}}{V_{dc}}$$

Equipments:

1. p-n junction diode (1N4007) ×4
2. Resistor (10kΩ) - ×1
3. Capacitors (1μF, 4.7μF) - 1 each
4. Function Generator
5. ~~ss~~ Oscilloscope
6. Bread board
7. Chords and wires.

Experimental Observation

1. **HW Rectifier without Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4.88 v
   Average or DC output voltage, V_{dc} (multimeter in DC mode) = 1.513 V
   RMS or AC output voltage, V_{r-rms} (multimeter in AC mode) = 1.866v

2. **HW Rectifier with 1μF Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4.84v
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = ~~3.451v~~ 2.56v
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = ~~3.5415~~ 3.451 v
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0.760v
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0.2146

3. **HW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4.60v
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 1.00v
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 4.27v
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0,222v
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0.05199

Theoretical Calculation (Homework)

1. **HW Rectifier Without Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 5.12V
   Peak input voltage, V_m = 5.85
   Diode voltage, $V_{D0} = 0.7$ V
   DC output voltage of the rectifier, $V_{dc} = \frac{V_m}{\pi} - \frac{V_{D0}}{2}$ = 1.512V
   RMS or AC output voltage, $V_{r-rms} = \frac{V_p}{2}$ = 2.56 V

2. **HW Rectifier With 1μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4.96 V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (see the experimental observation)= 2.64v
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 3.64v
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0.762v
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0.2098

3. **HW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4.88 V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (see the experimental observation) = 0.88 V
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 4.44v
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0.254v
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0.057

7. Also measure V_o with a multimeter in dc and ac mode and calculate the ripple factor.

8. Replace 1μF Capacitor with 4.7μF and repeat steps 4-7.

Experimental Observation

1. **FW Rectifier without Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4.48V
   Average or DC output voltage, V_{dc} (multimeter in DC mode) = 2.267V
   RMS or AC output voltage, V_{r-rms} (multimeter in AC mode) = 1.374V

2. **FW Rectifier with 1μF Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4.34V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 1.68V
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 3.376V
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0.401V
   Ripple factor, r = V_{r-rms}/V_{dc} = 0.11877

3. **FW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4.05V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 78
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 3.75 V
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0.187V
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0.048

Theoretical Calculation (Homework)

1. **FW Rectifier without Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4.48V
   Peak input voltage, V_m = 5.85 V
   Diode voltage, $V_{D0} = 0.7$ V
   DC output voltage of the rectifier, $V_{dc} = \frac{2\,V_m}{\pi} - 2\,V_{D0}$ = 2.324V
   RMS or AC output voltage, $V_{r-rms} = \frac{V_p}{\sqrt{2}}$ = 3.168V

2. **FW Rectifier with 1μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4.44V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (see the experimental observation) = 1.32 V
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 3.78V
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0.38V
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0.100V

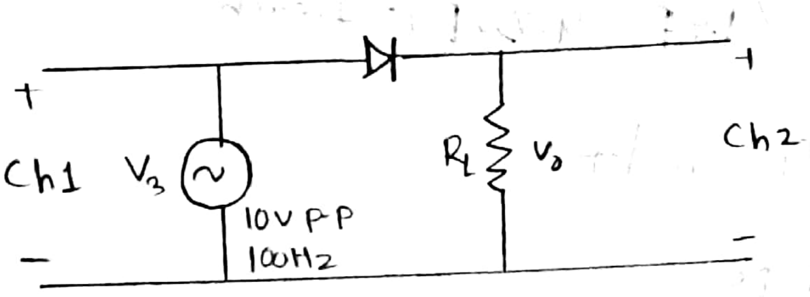
3. **FW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4.28V
   Peak to peak ripple voltage, V_p (see the experimental observation) = 0.44 V
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 4.06V
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0.127V
   Ripple factor, r = V_{r-rms}/V_{dc} = 0.03

Table:

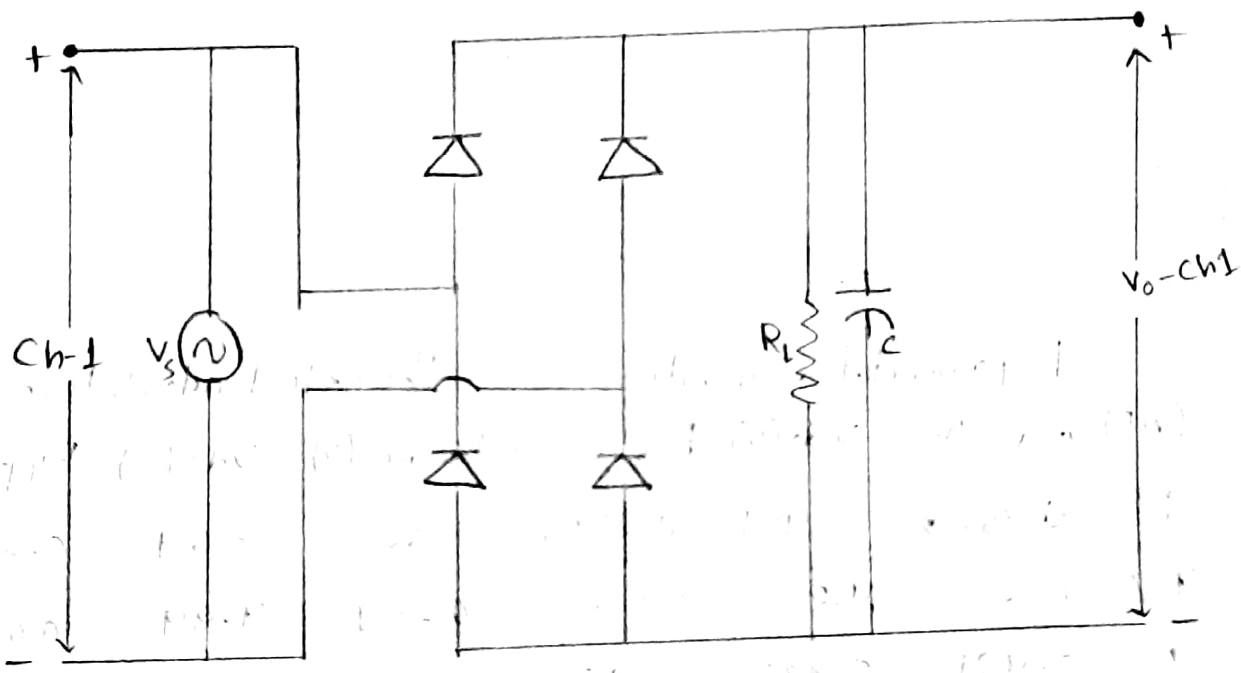
		Experimental observation			Theoretical calculation		
	C(μF)	V_{r-rms}(V)	V_{dc}(V)	Ripple factor	V_{r-rms}(V)	V_{dc}(V)	Ripple factor
HW	1	0.760	3.451	0.2146	0.762	3.64	0.209
	4.7	0.222	4.27	0.05199	0.254	4.44	0.057
FW	1	0.401	3.376	0.11877	0.38	3.78	0.100
	4.7	0.187	3.75	0.048	0.127	4.06	0.03

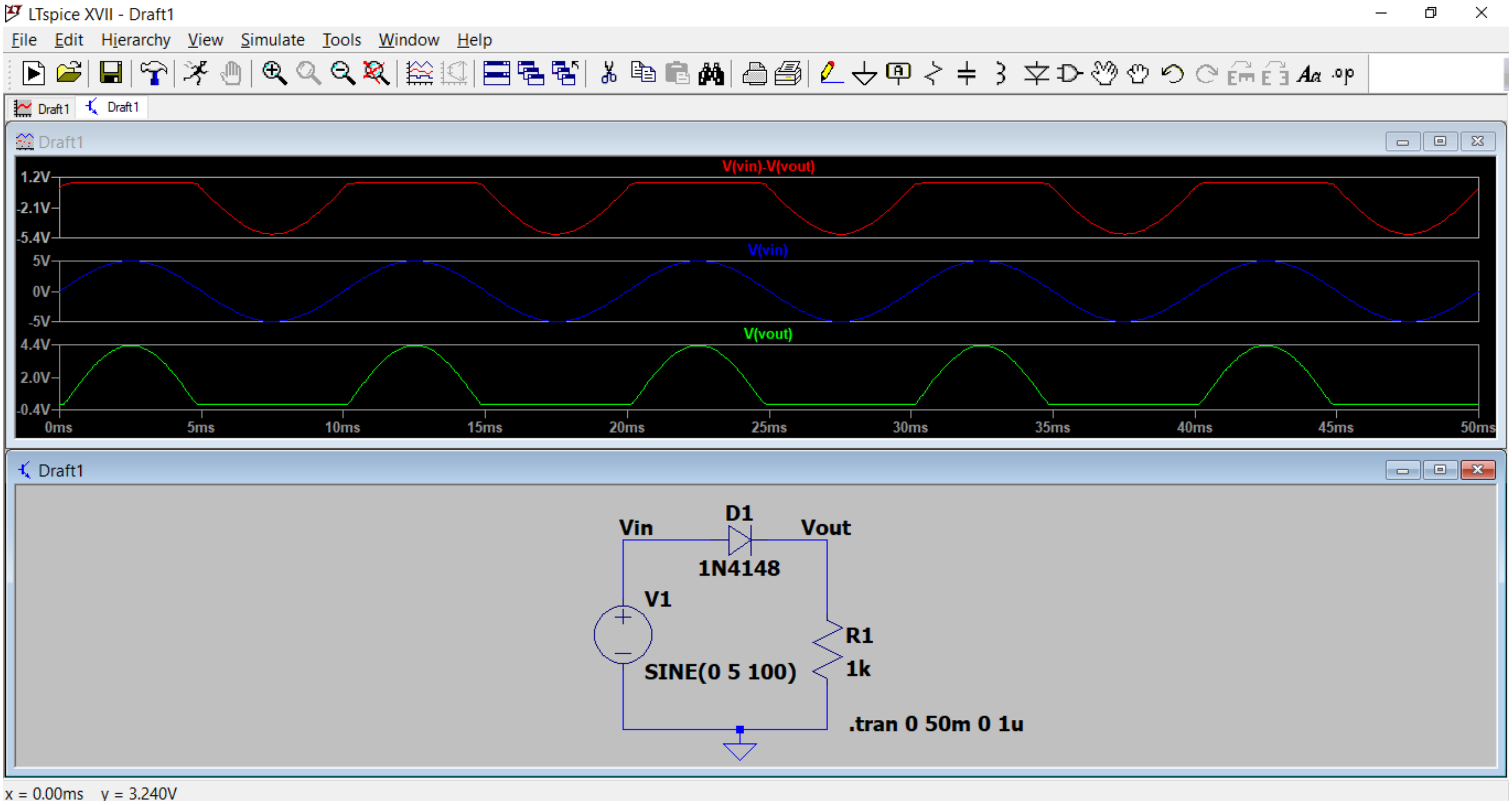
Circuit diagrams:

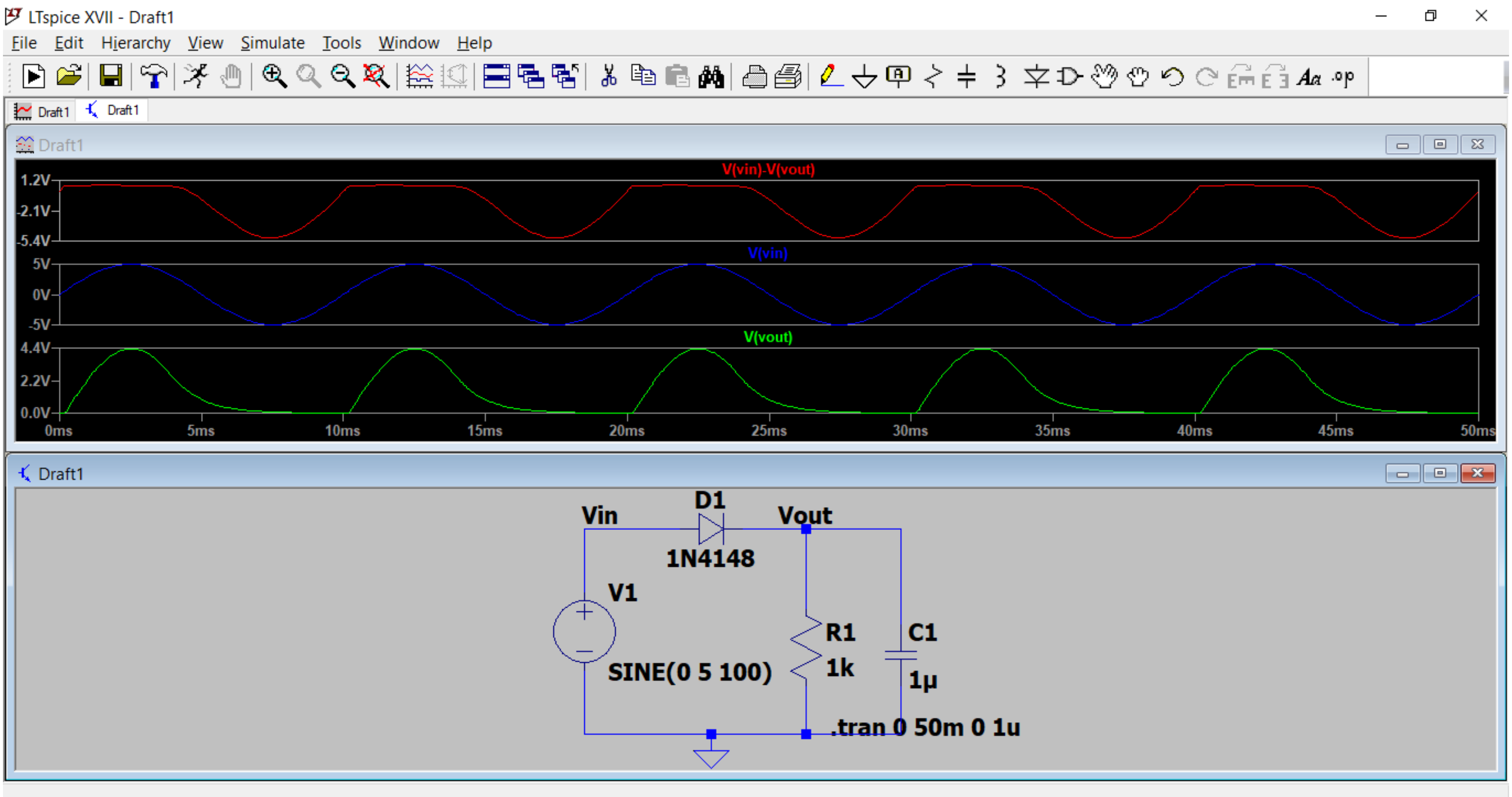
(I) Half-Wave rectifier

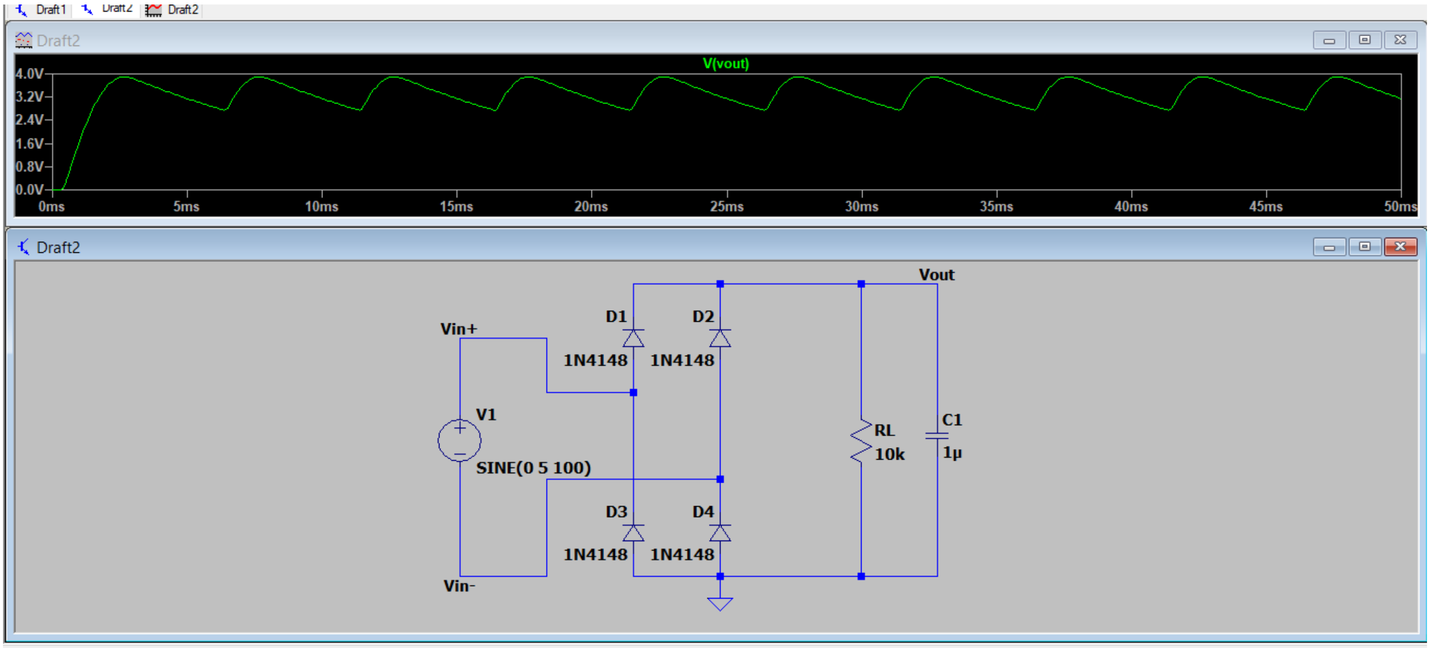


(II) Fullwave rectifier

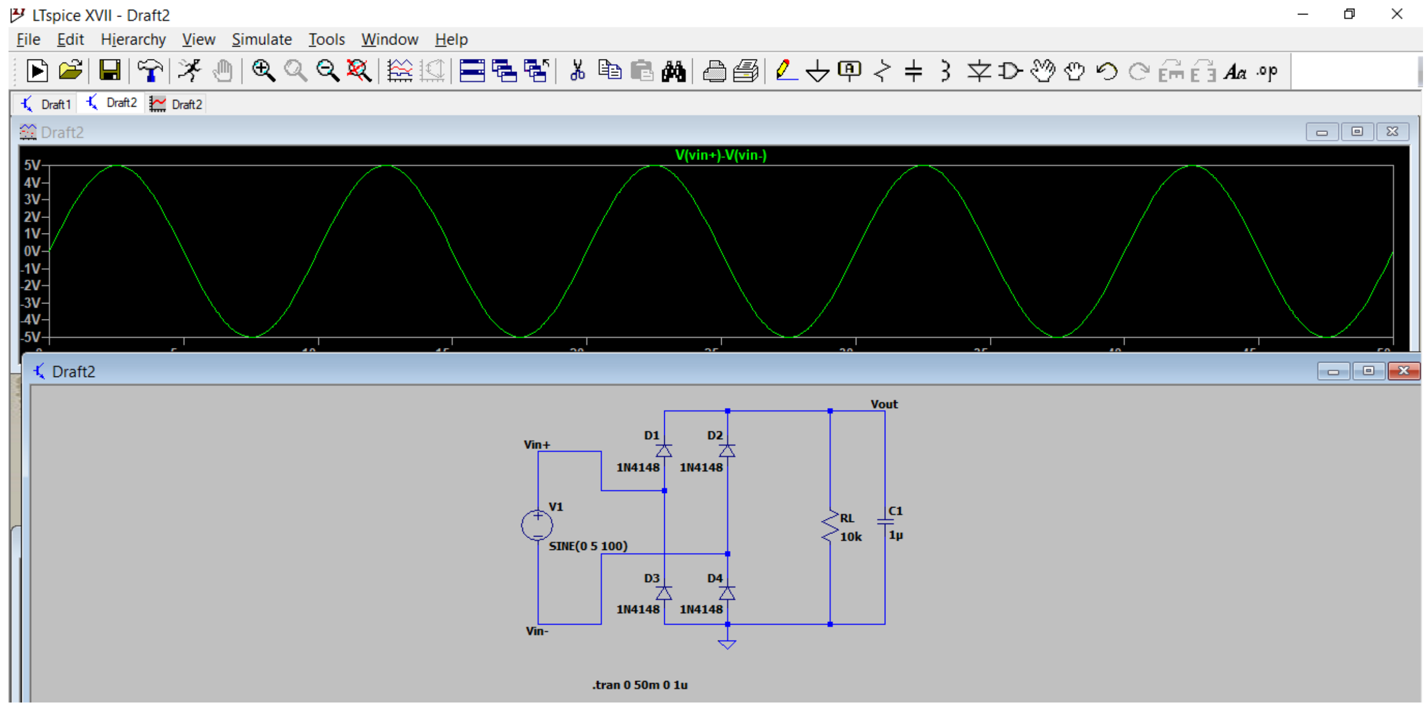



LTspice XVII - Draft1
File Edit Hierarchy View Simulate Tools Window Help
V(vin)-V(vout)
V(vin)
V(vout)
0ms 5ms 10ms 15ms 20ms 25ms 30ms 35ms 40ms 45ms 50ms
Vin
D1
Vout
1N4148
V1
R1
1k
SINE(0 5 100)
.tran 0 50m 0 1u
x = 0.00ms y = 3.240V

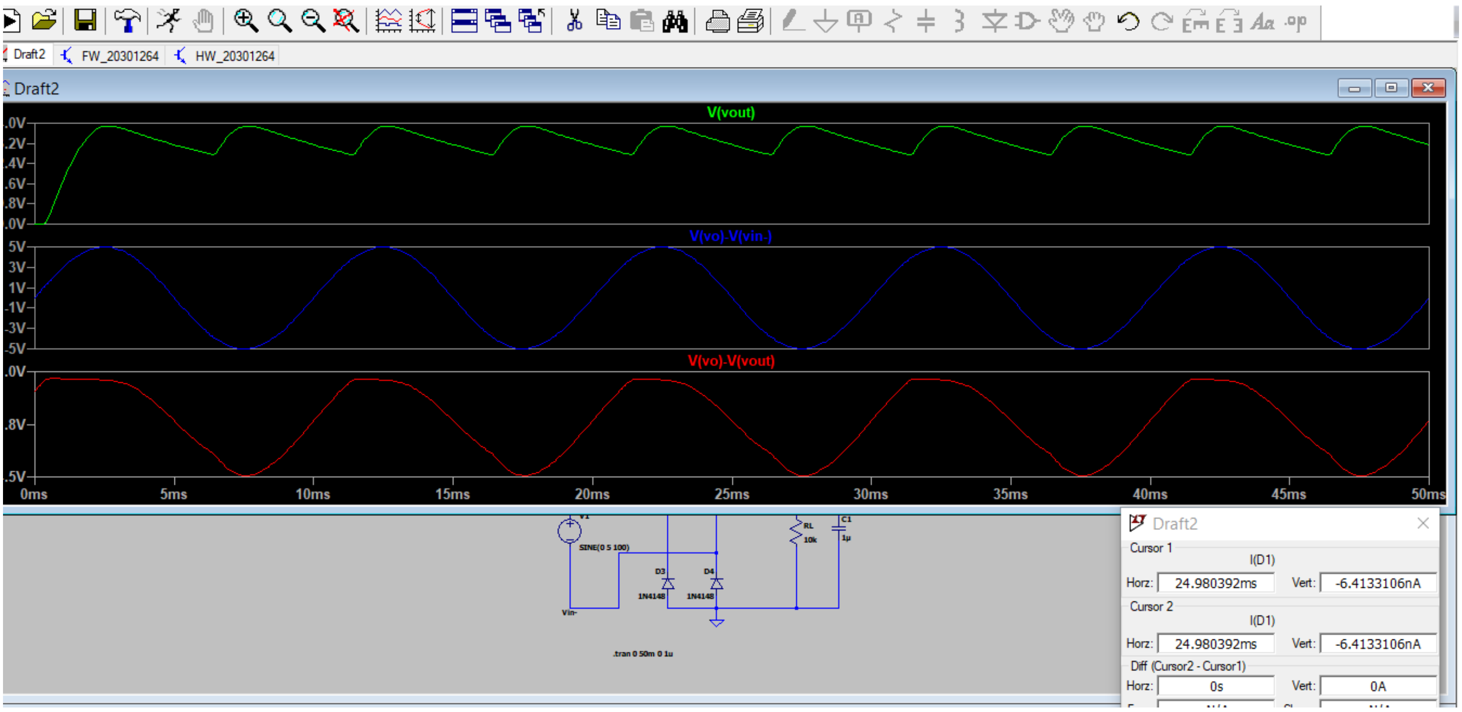

LTspice XVII - Draft1
File Edit Hierarchy View Simulate Tools Window Help
V(vin)-V(vout)
V(vin)
V(vout)
0ms 5ms 10ms 15ms 20ms 25ms 30ms 35ms 40ms 45ms 50ms
Vin
D1
Vout
1N4148
V1
R1
1k
C1
1µ
SINE(0 5 100)
.tran 0 50m 0 1u



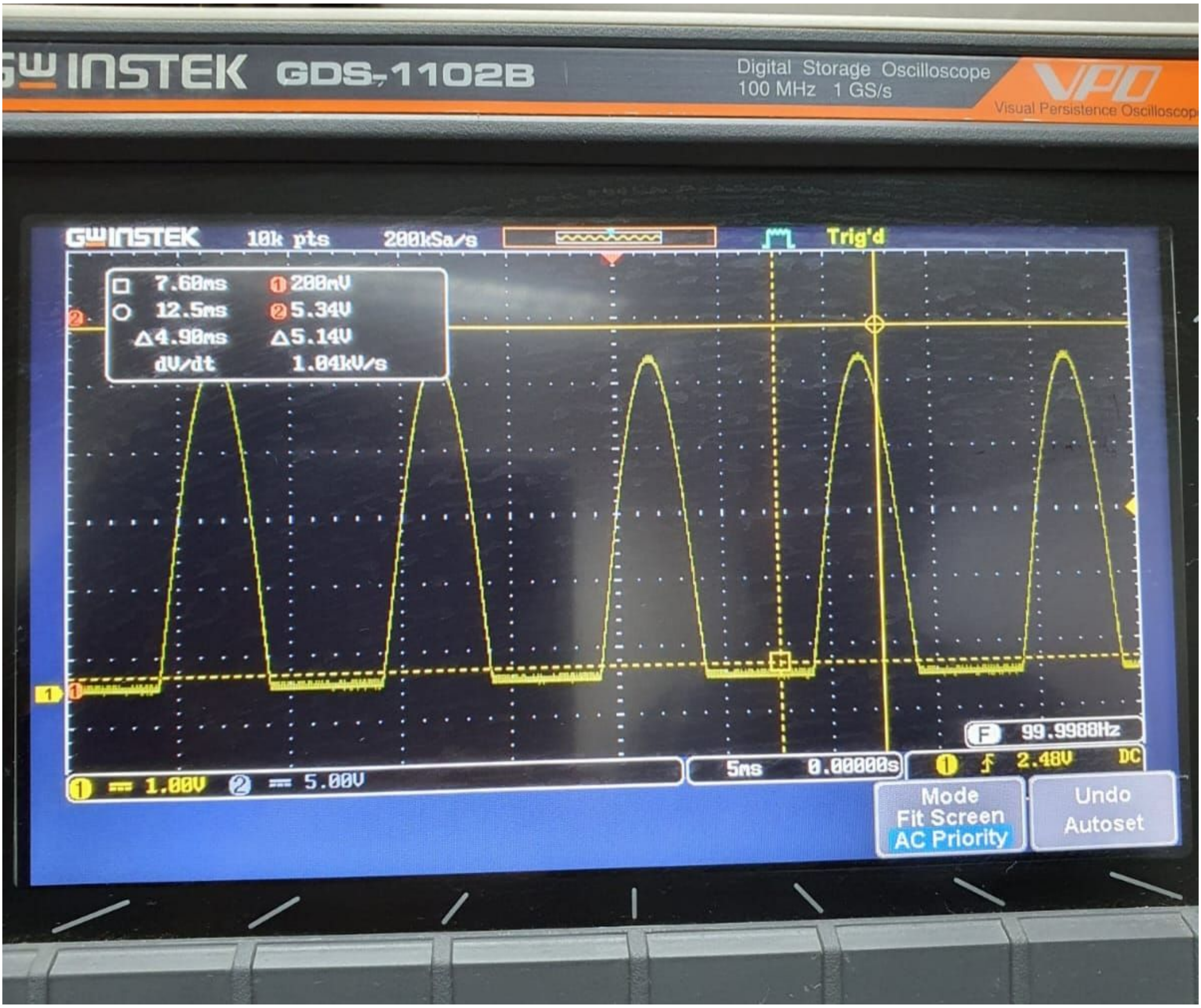
Draft1
Draft2
Draft2
V(vout)
4.0V
3.2V
2.4V
1.6V
0.8V
0.0V
0ms
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
Draft2
Vout
D1
D2
1N4148
1N4148
Vin+
V1
SINE(0 5 100)
RL
10k
C1
1µ
D3
D4
1N4148
1N4148
Vin-

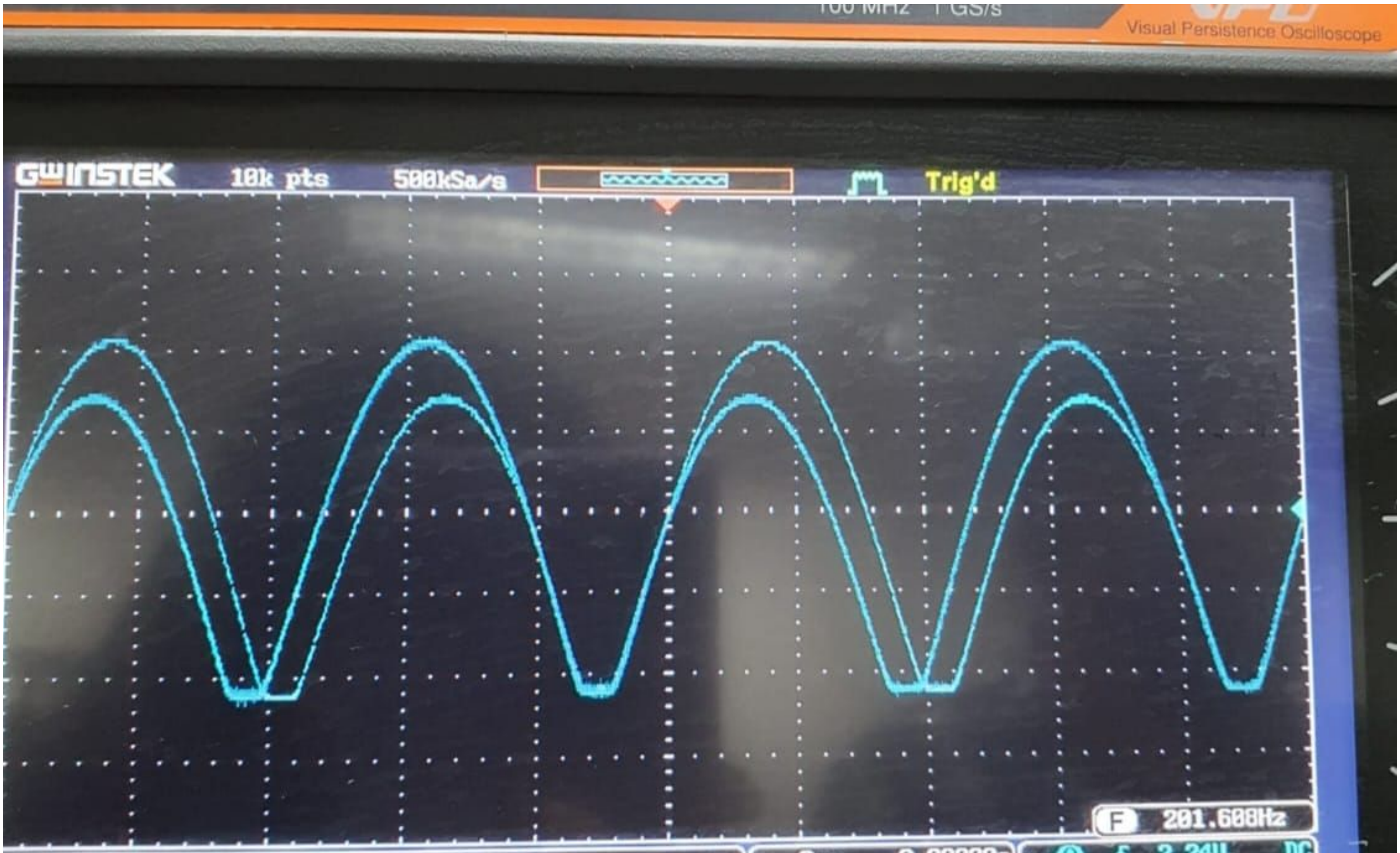


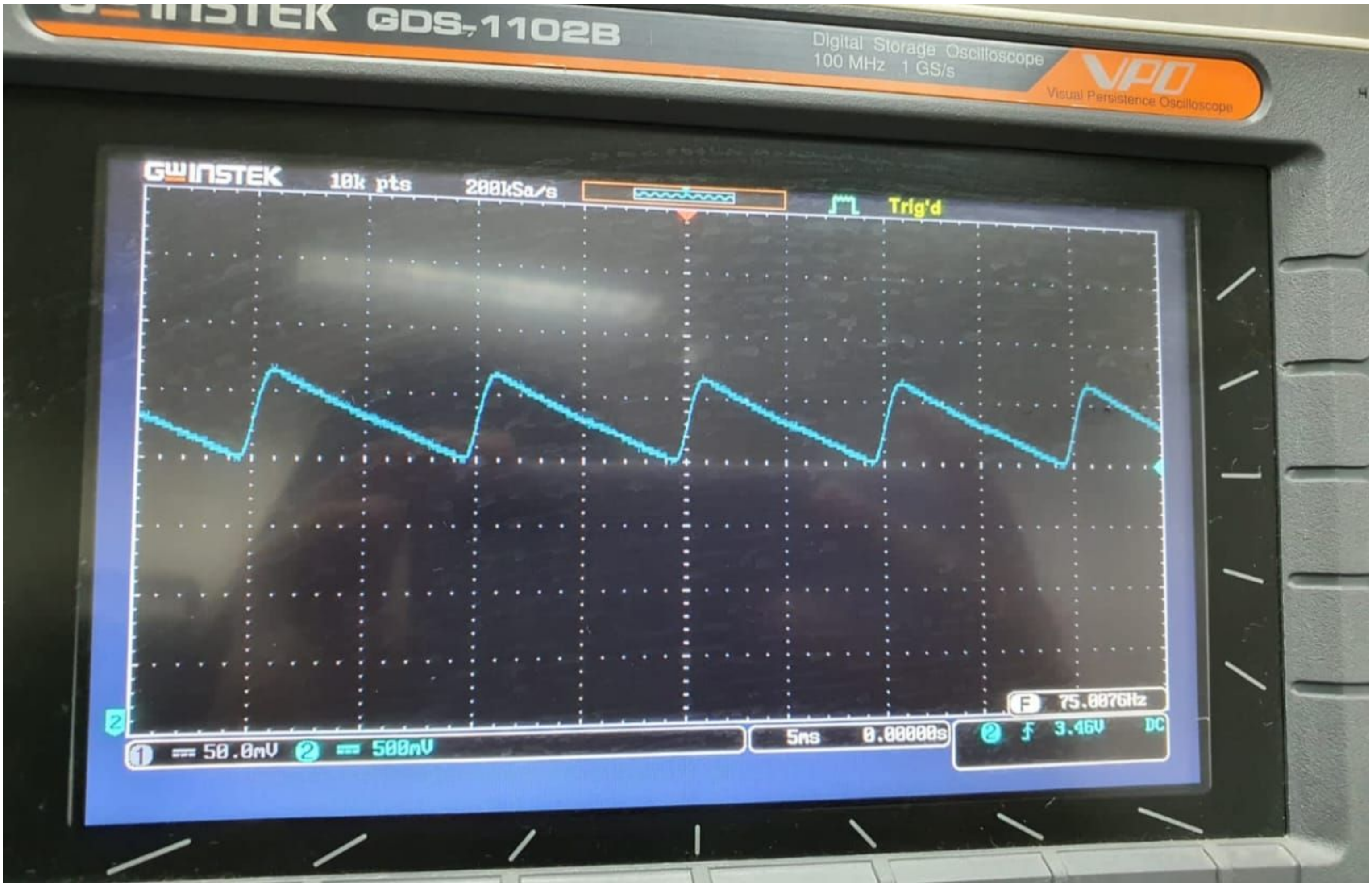
LTspice XVII - Draft2
File
Edit
Hierarchy
View
Simulate
Tools
Window
Help
Draft1
Draft2
Draft2
Draft2
V(vin+)-V(vin-)
5V
4V
3V
2V
1V
0V
-1V
-2V
-3V
-4V
-5V
Draft2
Vout
D1
D2
1N4148
1N4148
Vin+
V1
SINE(0 5 100)
RL
10k
C1
1µ
D3
D4
1N4148
1N4148
Vin-
.tran 0 50m 0 1u

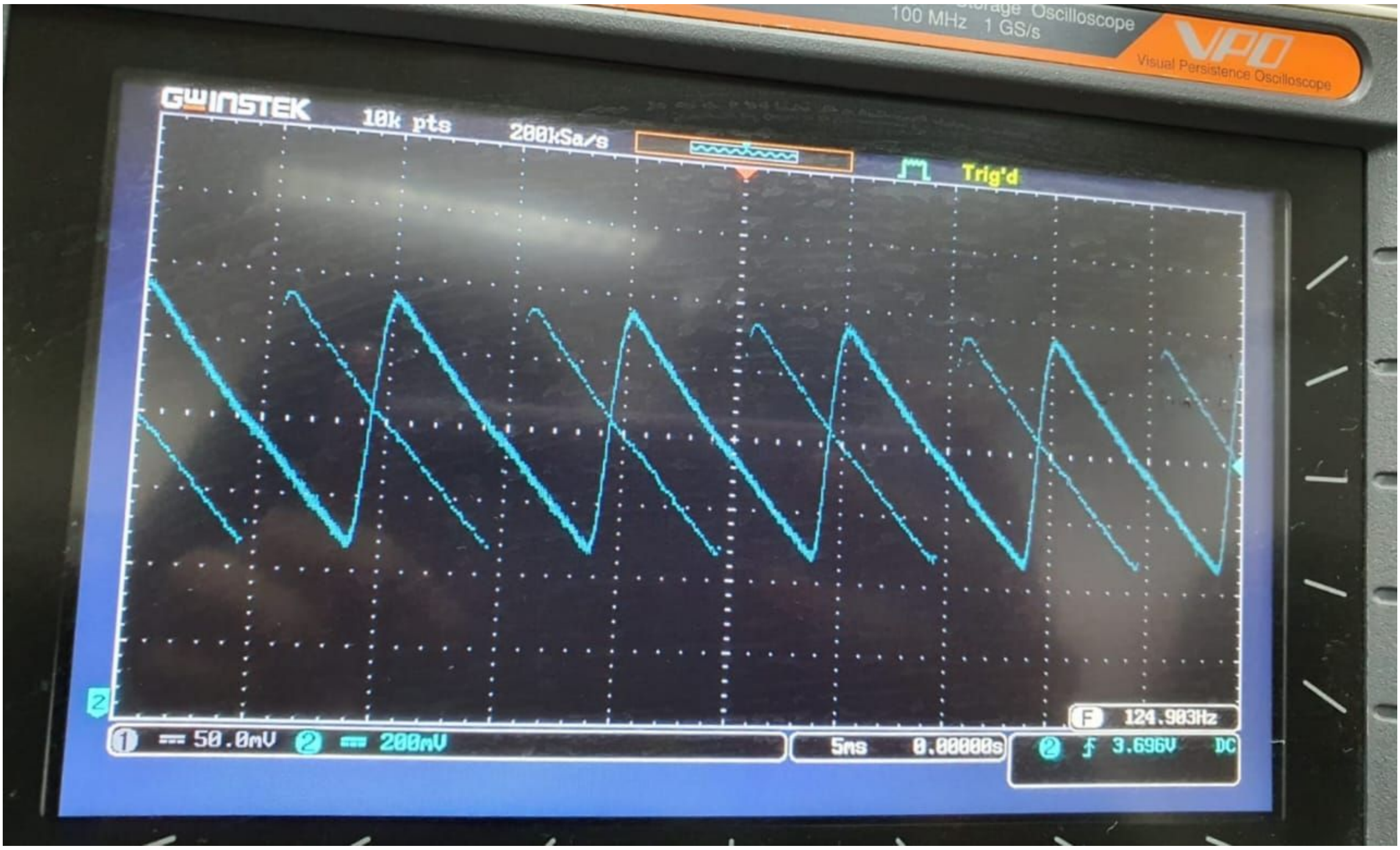


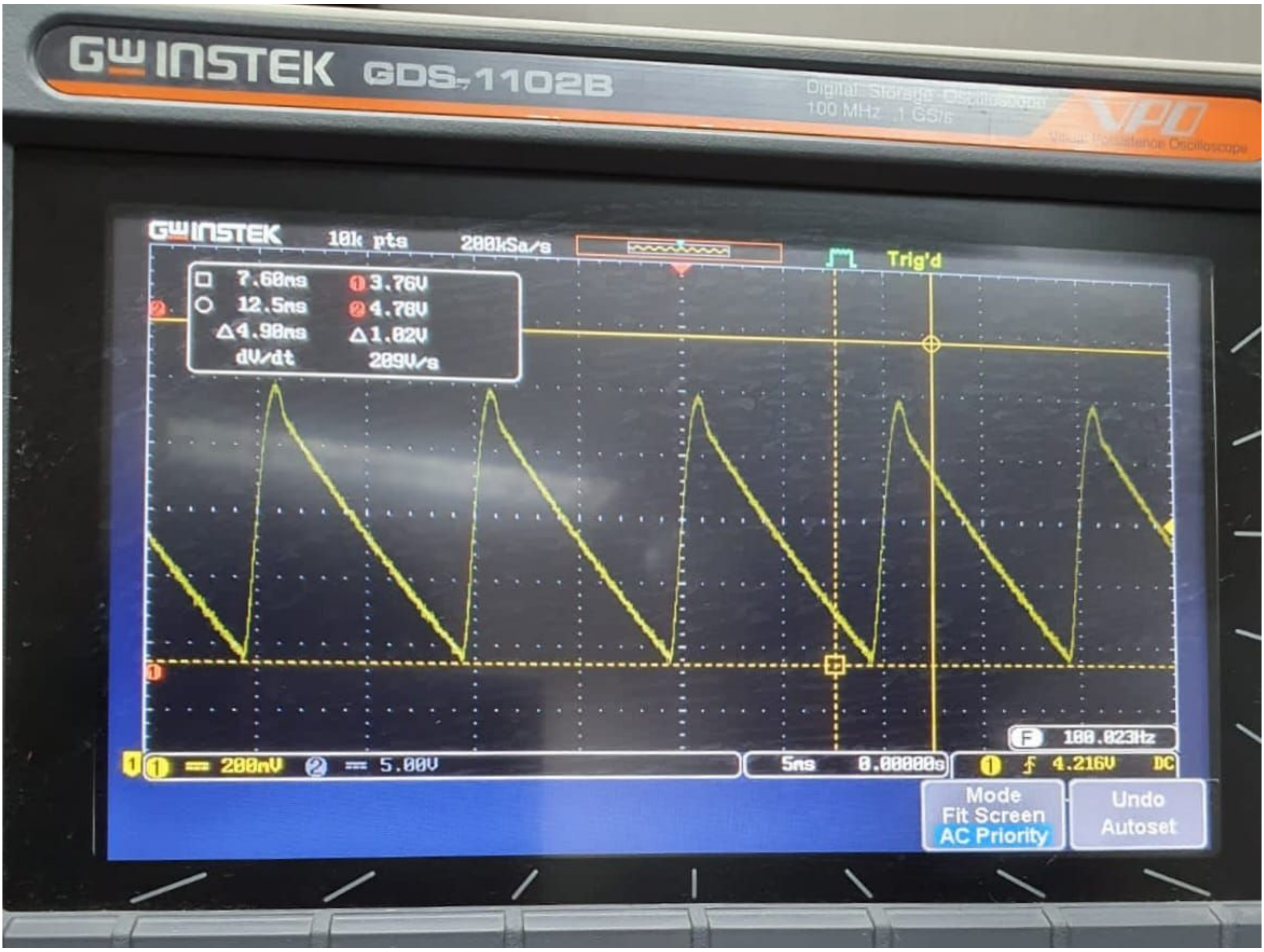
Draft2
FW_20301264
HW_20301264
Draft2
V(vout)
V(vo)-V(vin-)
5V
3V
1V
-1V
-3V
-5V
V(vo)-V(vout)
0ms
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
.tran 0 50m 0 1u
Draft2
Cursor 1
I(D1)
Horz: 24.980392ms
Vert: -6.4133106nA
Cursor 2
I(D1)
Horz: 24.980392ms
Vert: -6.4133106nA
Diff (Cursor2 - Cursor1)
Horz: 0s
Vert: 0A


GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
VPO
Visual Persistence Oscilloscope
GW INSTEK
10k pts
200kSa/s
Trig'd
7.60ms
12.5ms
Δ4.90ms
dV/dt
200mV
5.34V
Δ5.14V
1.04kV/s
99.9988Hz
1.00V
5.00V
5ms
0.00000s
2.48V
DC
Mode
Fit Screen
AC Priority
Undo
Autoset


Visual Persistence Oscilloscope
GW INSTEK
10k pts
500kSa/s
Trig'd
201.608Hz


GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
VPO
Visual Persistence Oscilloscope
GW INSTEK
10k pts
200kSa/s
Trig'd
75.0076Hz
50.0mV
500mV
5ms
0.00000s
3.46V
DC


100 MHz 1 GS/s
VPO
Visual Persistence Oscilloscope
GW INSTEK
10k pts
200kSa/s
Trig'd
124.983Hz
50.0mV
200mV
5ms
0.00000s
3.696V
DC


GW INSTEK GDS-1102B
Digital Storage Oscilloscope
100 MHz 1 GS/s
GW INSTEK
10k pts
200kSa/s
Trig'd
7.60ms
12.5ms
Δ4.90ms
dV/dt
3.76V
4.78V
Δ1.02V
209V/s
100.023Hz
200mV
5.00V
5ms
0.00000s
4.216V
DC
Mode
Fit Screen
AC Priority
Undo
Autoset

$V_{max} = 5.36$ (V_p)

R = 10.08 kΩ

$V = 10.08$

$V_{DC} = 328.7$ mv

$V_{Rms} \leftarrow V_{AC} = 3.58$ V

H/W without capacitor

$V_p = 4.88$ V

$V_{DC} = \cancel{1.866}$ 1.513 V

$V_{Rms} \leftarrow V_{AC} = 1.866$

H/W with filter capacitor (1μF)

$V_p = 4.84$ V

Pk-Pk = 2.56 V

$V_{DC} = 3.451$ V

$V_{Rms} = 0.760$ V

H/W with filter capacitor (4.7μF)

$V_p = \cancel{4.68}$ $\cancel{5.000}$ 4.60 V

Pk-Pk = 1.00 V

$V_{DC} = 4.27$ V

$V_{Rms} = 0.222$ V

FW without capacitor

V_p = ~~4.86~~ 4.48 v

Pk-Pk = 4.44v

V_{DC} = 2.267

V_{Rms} = 1.374 v

F.W with ~~1μ~~F

V_p = 4.34

Pk-Pk = 1.68

V_{DC} = 3.376 V

V_{Rms} = 0.401 V

F.W with 4.7 μF

V_p = 4.05 V

Pk - Pk = 78

V_{DC} = 3.75 V

V_{Rms} = 0.182 V

Ankan 16/10/22

• Which of two rectifier is better?

⇒ I think full wave rectifier is better than half wave rectifier because the average output voltage is higher in full-wave rectifier, also there is less ripple produced in full-wave rectifier when compared to the half-wave rectifier.

• Why can't you see the input and output using 2 channels of oscilloscope simultaneously?

⇒ Usually because an oscilloscope has ground-referenced inputs, and connecting both channels directly would short out portions of the rectifier bridge.

You can certainly make this observation using a scope but you need a scope with floating input channels, or external differential ~~problems~~ probes.

• Challanges during expering:

⇒ The things that we found challanging while experiment such as, full wave rectifier was harder to implement.

We cannot see input and output at chanel 1 and channel at the same time on oscilloscopes for full wave rectifier.