CSE251: ELECTRONIC DEVICES AND CIRCUITS

EXPERIMENT 4:
STUDY OF HALF-WAVE
& FULL-WAVE RECTIFIERS

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Data Sheet

Experimental Observation: HW Rectifier

1. **HW Rectifier without Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 4·29V
   Average or DC output voltage, V_{dc} (multimeter in DC mode) = 1·24 V
   RMS or AC output voltage, V_{r-rms} (multimeter in AC mode) = 1·599 V

2. **HW Rectifier with 1μF Capacitor:** C = 0·97 μF
   Peak output voltage, V_p (oscilloscope) = 4·29 V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 3·44 V
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 2·23
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 1·062
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0·476

3. **HW Rectifier with 4.7μF Capacitor:** C = 4·86 μF
   Peak output voltage, V_p (oscilloscope) = 4·08V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 1·28V
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 3·387V
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0·378
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0·116

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Theoretical Calculation: HW Rectifier

1. **HW Rectifier Without Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4·29
   Peak input voltage, V_m = 5V
   Diode voltage, $V_{D0} = 0.7$ V
   DC output voltage of the rectifier, $V_{dc} = \frac{V_m}{\pi} - \frac{V_{D0}}{2}$ = 1·29 V
   RMS or AC output voltage, $V_{r-rms} = \frac{V_p}{2}$ = 2·12

2. **HW Rectifier With 1μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4·24
   Peak to peak ripple voltage, $V_{r(p-p)}$ (see the experimental observation)= 3·44
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 2·52
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0·993
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0·394

3. **HW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 4·08
   Peak to peak ripple voltage, $V_{r(p-p)}$ (see the experimental observation) = 1·28
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 3·44
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0·3695
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0·1074

Experimental Observation: FW Rectifier

1. **FW Rectifier without Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 3·68V
   Average or DC output voltage, V_{dc} (multimeter in DC mode) = 2·061
   RMS or AC output voltage, V_{r-rms} (multimeter in AC mode) = 1·281

2. **FW Rectifier with 1μF Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 3·52V
   Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 1·76
   Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 2·621
   RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0·540
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0·206028

3. **FW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (oscilloscope) = 3·44 V

Peak to peak ripple voltage, $V_{r(p-p)}$ (oscilloscope) = 0'64V
Average or DC value of the ripple voltage, V_{dc} (multimeter in DC mode) = 3'069
RMS or AC value of the ripple voltage, V_{r-rms} (multimeter in AC mode) = 0'148
Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0'0482

Theoretical Calculation: FW Rectifier

1. **FW Rectifier without Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 3'68V
   Peak input voltage, V_m = 5V
   Diode voltage, $V_{D0} = 0.7$ V
   DC output voltage of the rectifier, $V_{dc} = \frac{2\,V_m}{\pi} - 2\,V_{D0}$ =
   RMS or AC output voltage, $V_{r-rms} = \frac{V_p}{\sqrt{2}}$ =

2. **FW Rectifier with 1μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 3'52
   Peak to peak ripple voltage, $V_{r(p-p)}$ (see the experimental observation) = 1'76
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 2'64
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0'508
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0'192

3. **FW Rectifier with 4.7μF Capacitor:**
   Peak output voltage, V_p (see the experimental observation) = 3'44
   Peak to peak ripple voltage, V_p (see the experimental observation) = 0'64
   DC value of the ripple voltage, $V_{dc} = V_p - \frac{V_{r(p-p)}}{2}$ = 3'12
   RMS value of the ripple voltage, $V_{r-rms} = \frac{V_{r(p-p)}}{2\sqrt{3}}$ = 0'184
   Ripple factor, $r = V_{r-rms}/V_{dc}$ = 0'058

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Table for Comparison

Use the experimental and theoretical data for comparison.

		Experimental Observation			Theoretical Calculation		
	C(uF)	Vr-rms (V)	Vdc (V)	Ripple Factor	Vr-rms (V)	Vdc (V)	Ripple Factor
HW	1	1.062	2.23	0.476	0'998	2'52	0'394
	4.7	0.378	3.387	0.116	0'3695	3'49	0'1074
FW	1	0.540	2.621	0.206098	0'508	2'64	0'192
	4.7	0.148	3.069	0.0482	0'184	3'12	0'058

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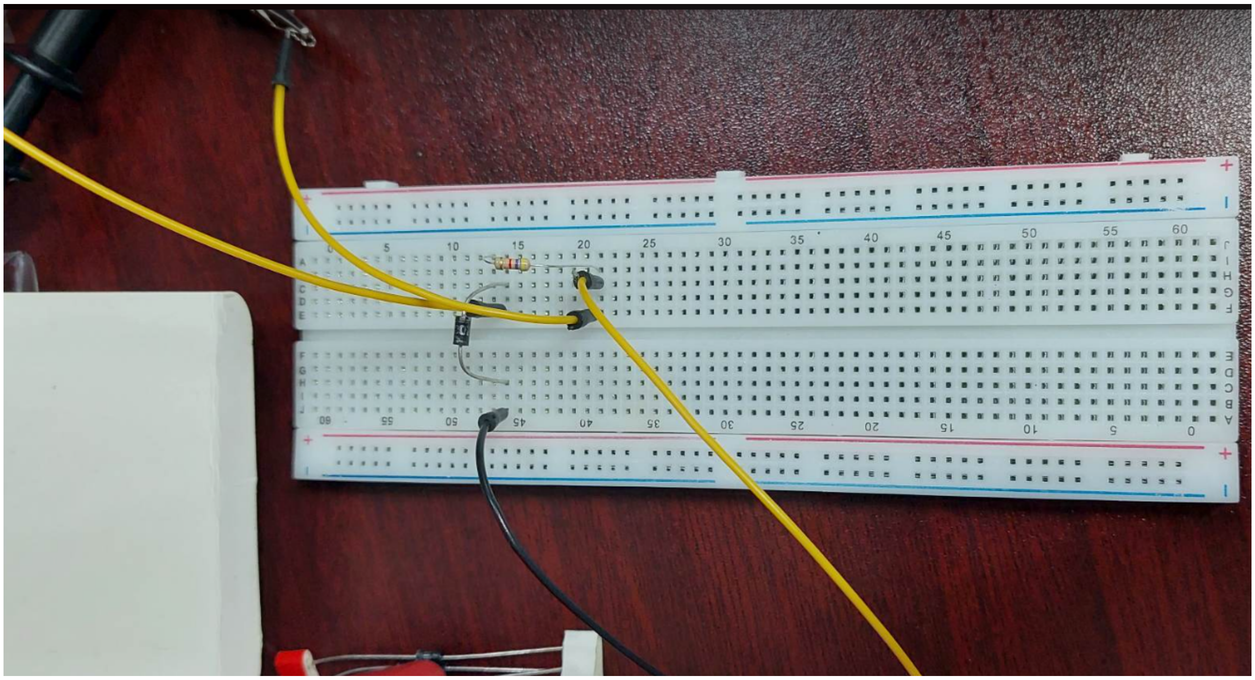
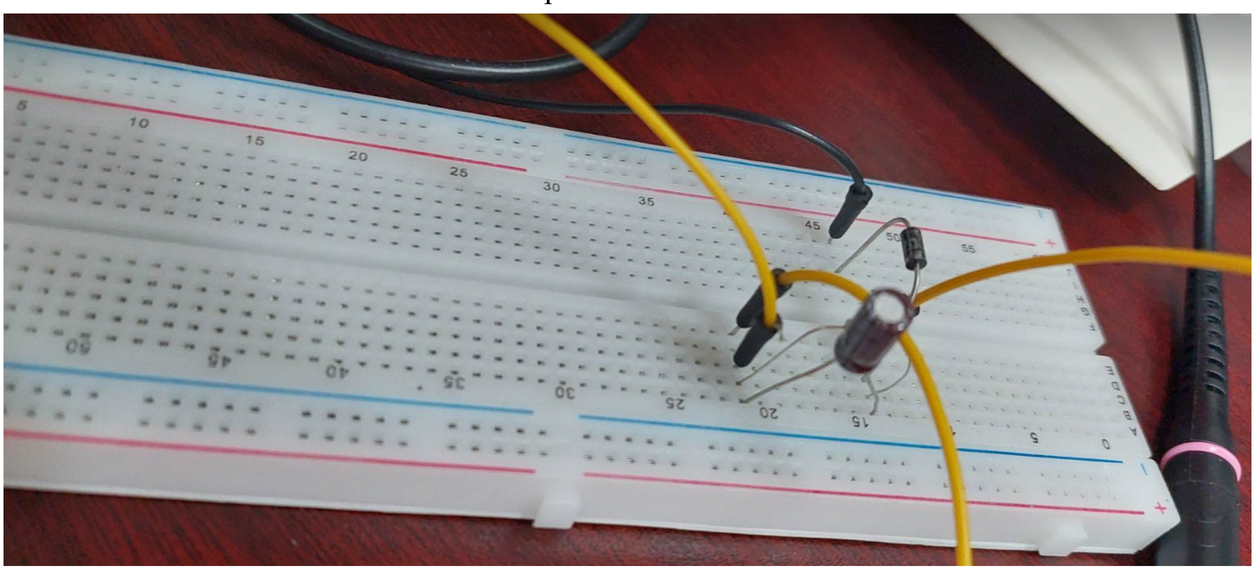
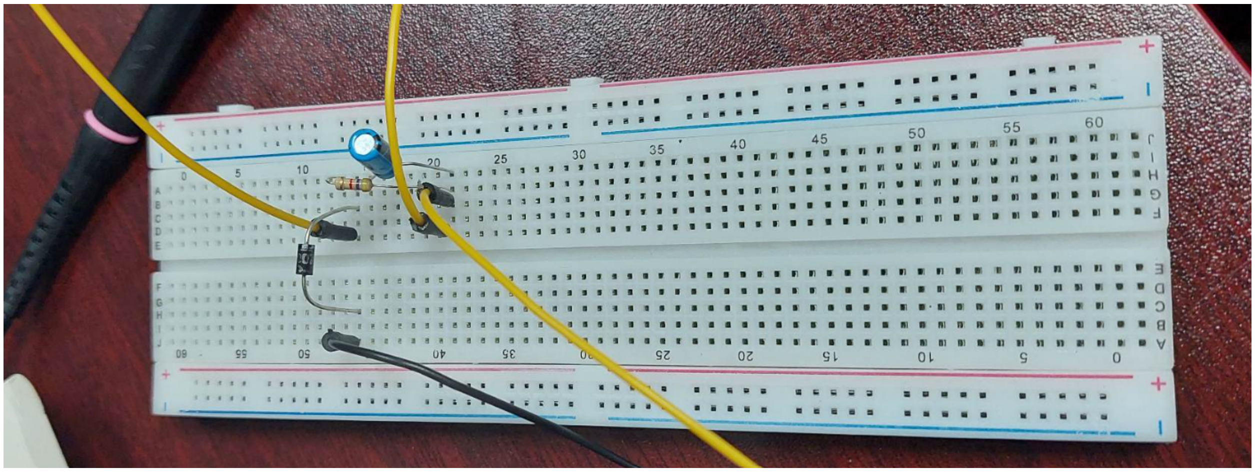
Circuit for Half-wave rectifier without capacitor :



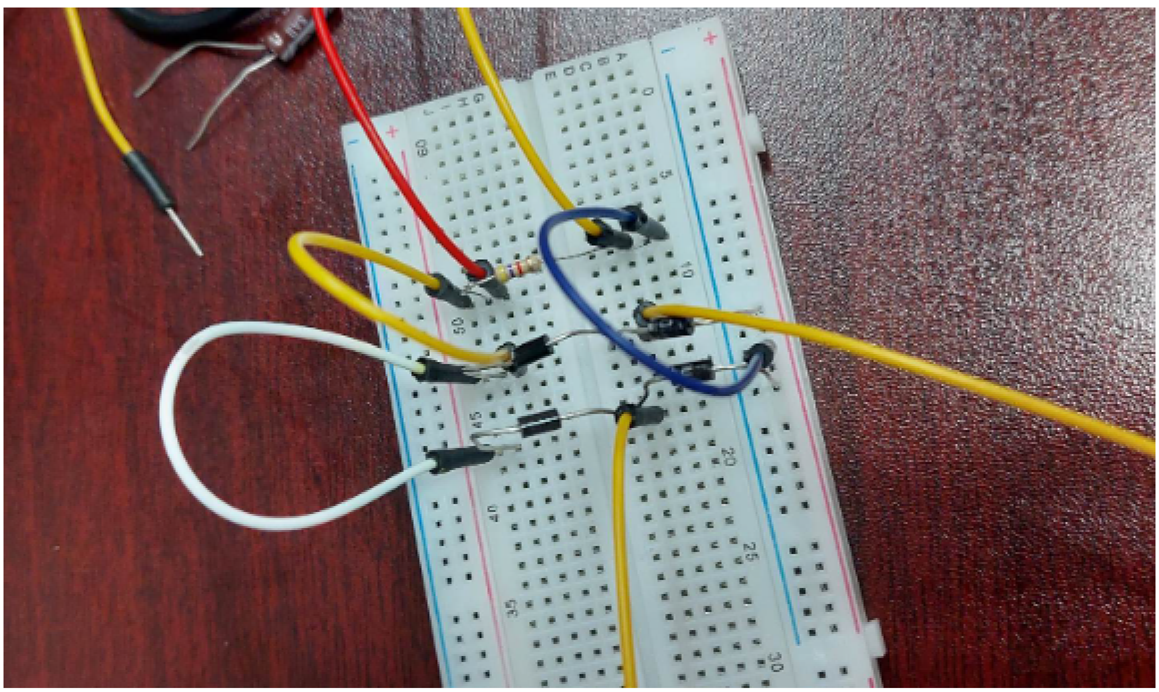
Circuit for Half-wave rectifier with 1uF capacitor :



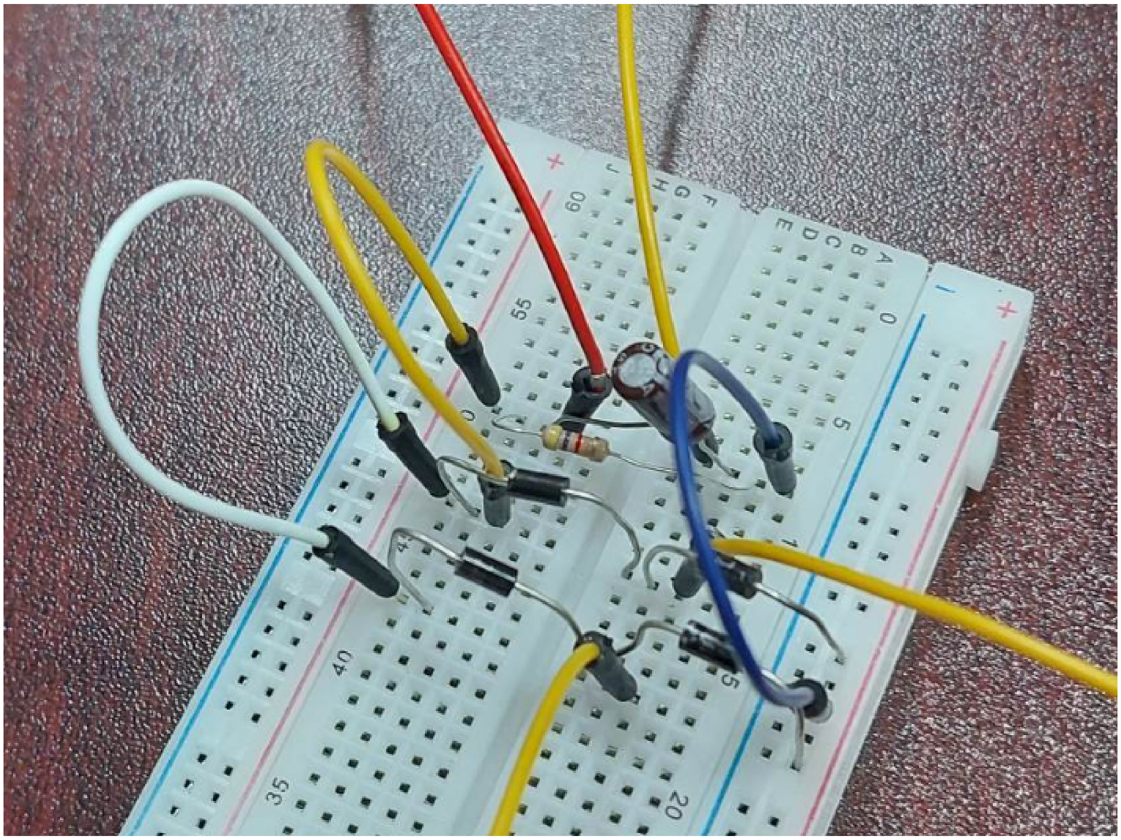
Circuit for Half-wave rectifier with 4.7uF capacitor :



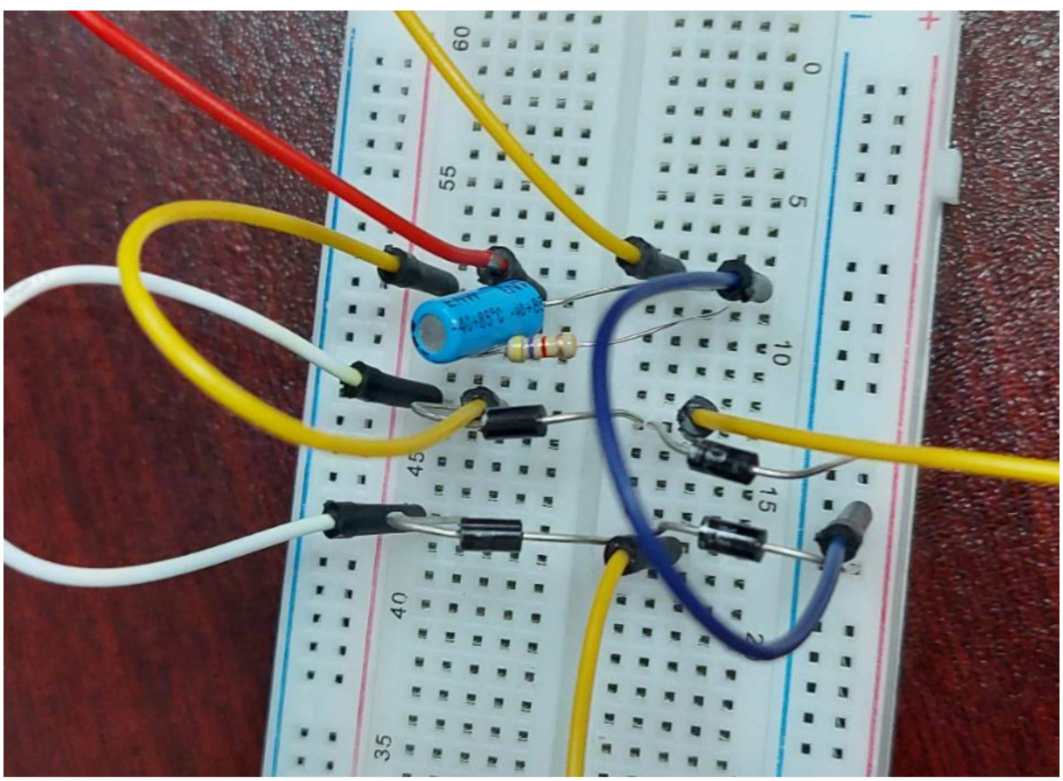
Circuit for Full-wave rectifier without capacitor :



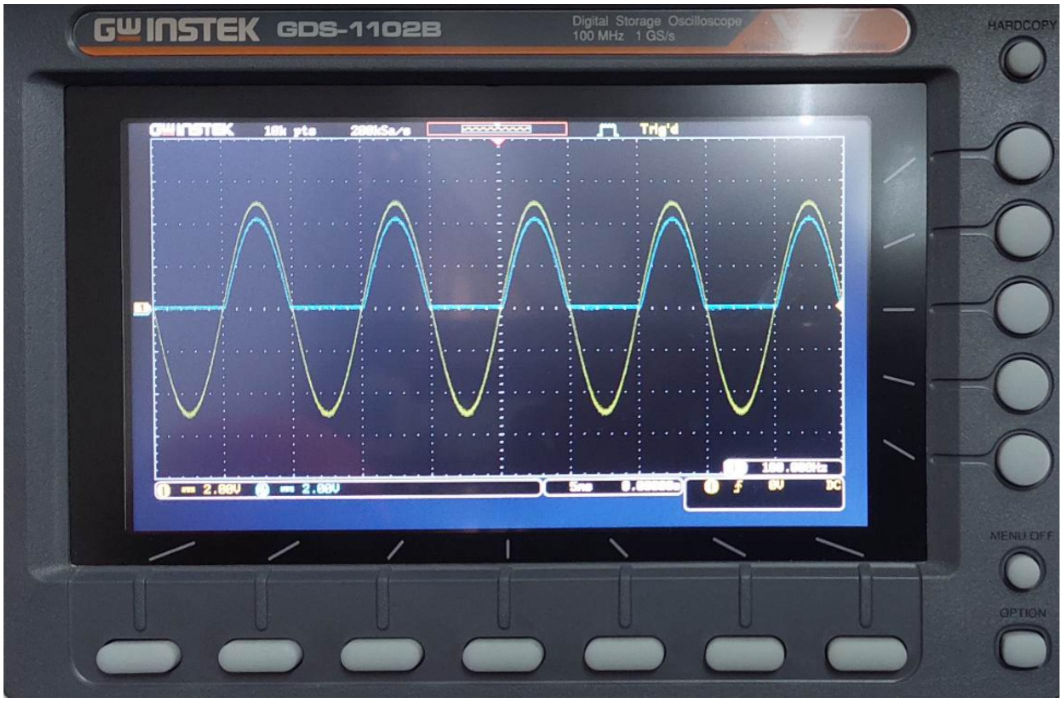
Circuit for Full-wave rectifier with 1uF capacitor :



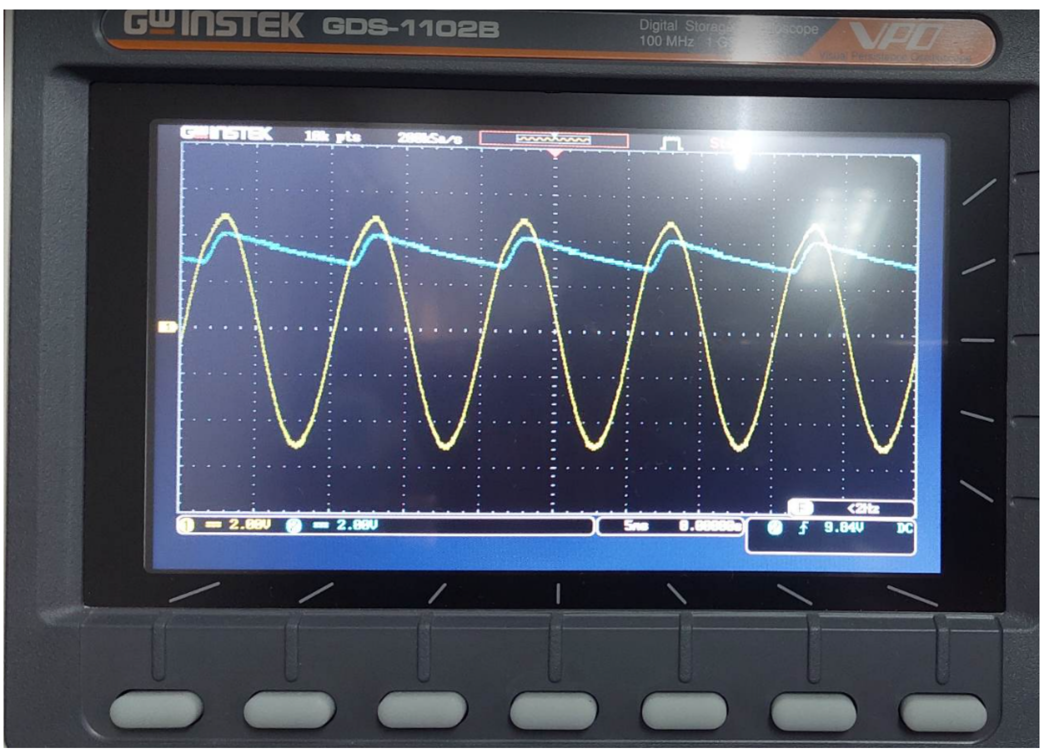
Circuit for Full-wave rectifier with 4.7uF capacitor :



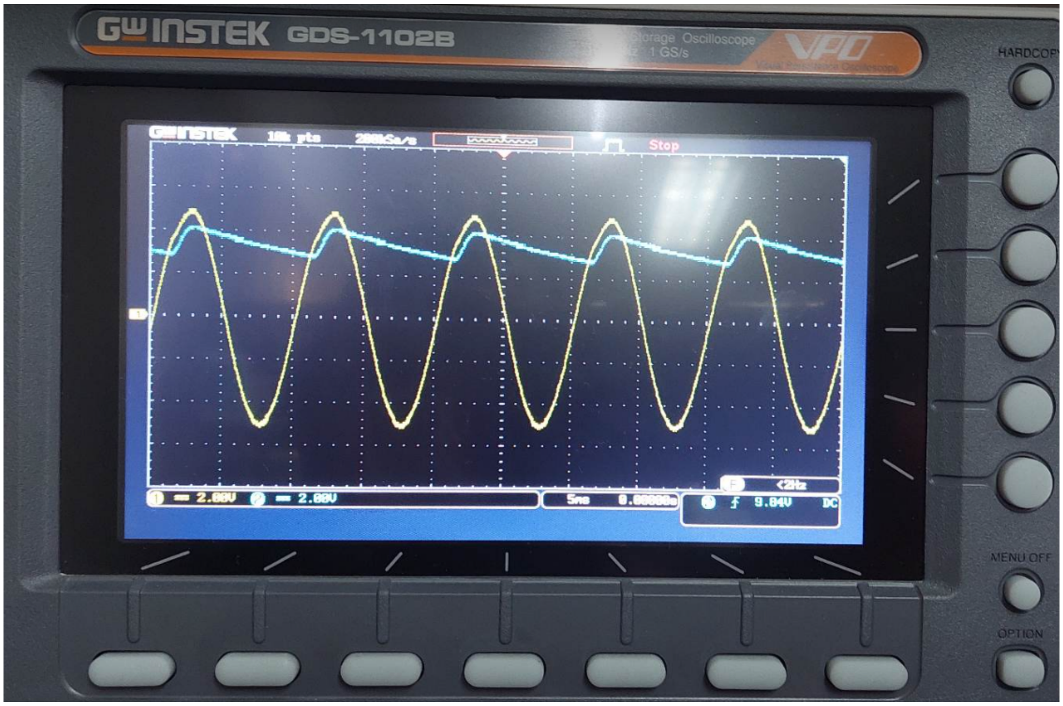
Input and output curves for Half-wave rectifier without capacitor :



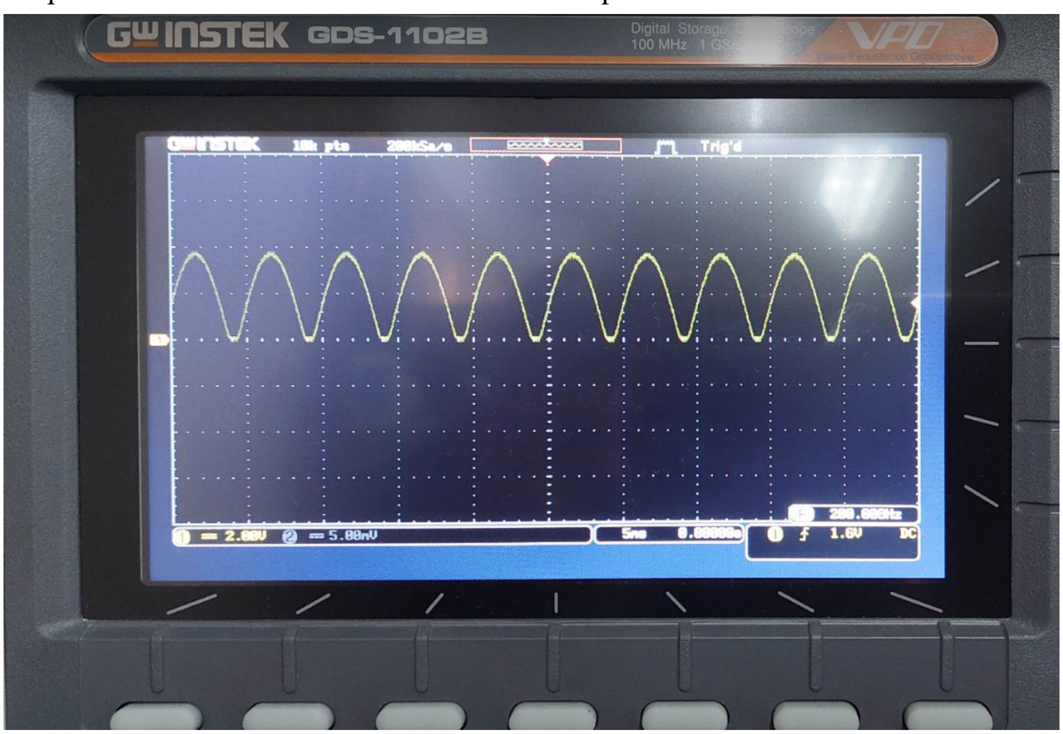
Input and output curves for Half-wave rectifier with 1uF capacitor :



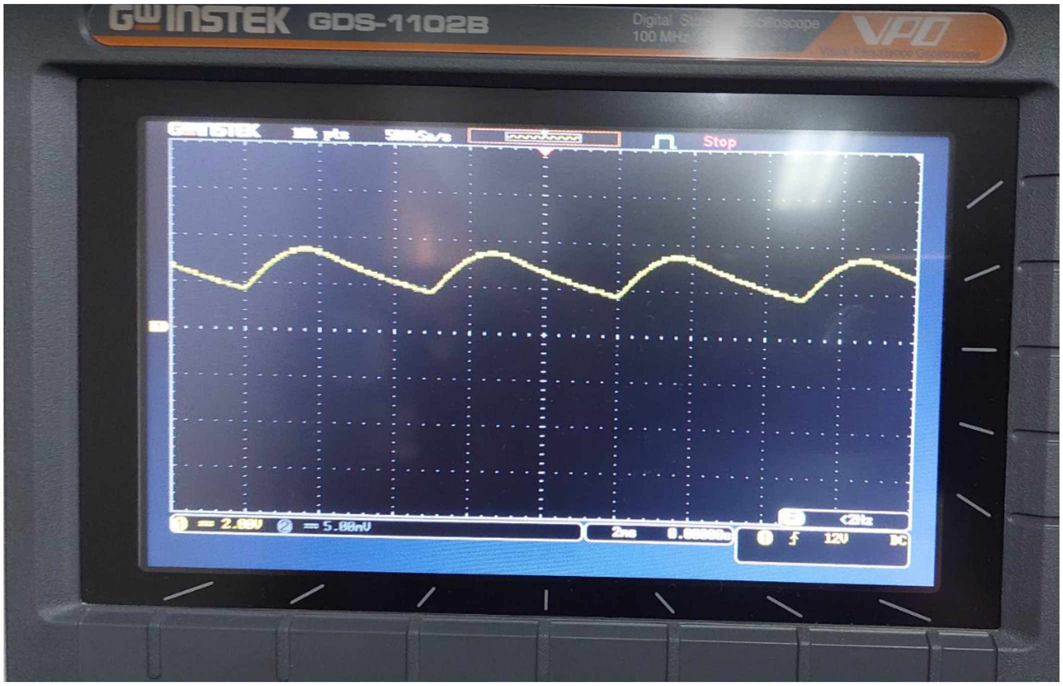
Input and output curves for Half-wave rectifier with 4.7uF capacitor :



Output curve for Full-wave rectifier without capacitor :



Output curve for Full-wave rectifier with 1uF capacitor :



Output curve for Full-wave rectifier with 4.7uF capacitor :

DISCUSSION :

First of all, the half-wave rectifier is built using a 100kΩ resistor and diode connected in series with a function generator set at 5V and 100Hz connected to the channel 1 of the oscilloscope and channel 2 of the oscilloscope is connected to the resistor. Then, input and output curves are observed on the oscilloscope using the channel 1 and channel 2 respectively. Further, 1uF and 4.7uF are connected to the resistor parallely one after another to observe the input and output curves to observe the smoothness of the curves caused by these capacitors.

Afterwards, a full-wave rectifier is built using two diodes connected in series and another two diodes connected in series. These are connected in parallel and the function generator is connected at the middle of both the series diodes. And, a 100kΩ resistor is connected in parallel to the diodes and channel 2 is connected to the resistor to observe the output curves. Again, 1uF and 4.7uF are connected to the resistors parallely one after another to observe the output curve to observe the smoothness of the curves caused by these capacitors.

Through the observations, the curves are more smooth using a 4.7uF capacitor for both half-wave and full-wave rectifiers. 4.7uF capacitor discharges and charges at a faster rate than 1uF, so the time taken to turn ON and OFF the diode becomes faster.

Among the half-wave and full-wave rectifiers, the full-wave rectifier is better because the diode does not turn OFF during the -ve half cycle, instead current flows through the circuit using the diodes which are in forward-bias during this process. As a result, there is an output voltage curve for both +ve and -ve half cycles producing a greater average output voltage and smaller ripple factor than the half-wave rectifier.

We cannot observe the input and output curves using only channel 2 because connecting both the inputs and outputs of the rectifiers to a single channel can be shorted the rectifier as the oscilloscope has ground referenced inputs.

The problem faced during the experiment was that the output curve of the full-wave rectifier contained noise. To eliminate the noise, a capacitor was connected to one of the wires connected to the resistor from where the channel 2 was connected.