



The Islamic University of Gaza

Faculty of Engineering

Department of Computer Engineering

Electronics I LAB

[LAB 04]

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Objectives

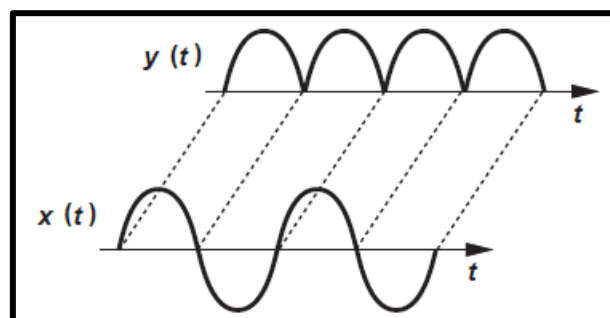
- To construct a full-wave rectifier circuit and analyze its output.
- To analyze the rectifier output using a capacitor in shunt as a filter.
- To be familiar how can be simulate full-wave-rectifier circuit using ltspice simulation.

Equipment

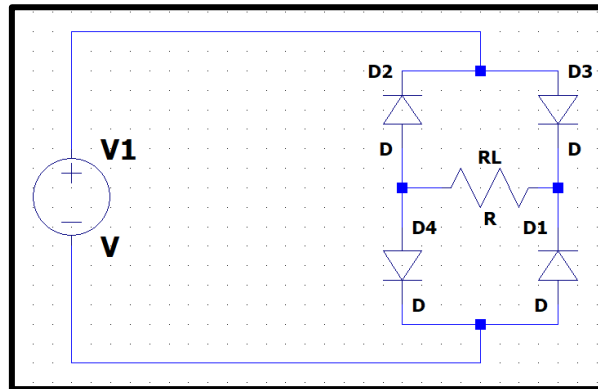
- Diode (1N4007).
- Resistors.
- Function generator.
- Oscilloscope.

Theory

In the half-wave rectifier configuration, only the positive half cycles of the input signal are utilized, while the negative half cycles are suppressed. This limitation forces the filter capacitor to discharge almost throughout the entire period, leading to a relatively large ripple voltage under heavy load conditions. A straightforward modification can effectively reduce the ripple by a factor of two. As illustrated in Figure 1, the improvement involves processing both the positive and negative halves of the input waveform, with the negative portion inverted before being applied to the output. This results in the well-known full-wave rectifier (FWR) circuit.



- **Bridge full wave circuit:**

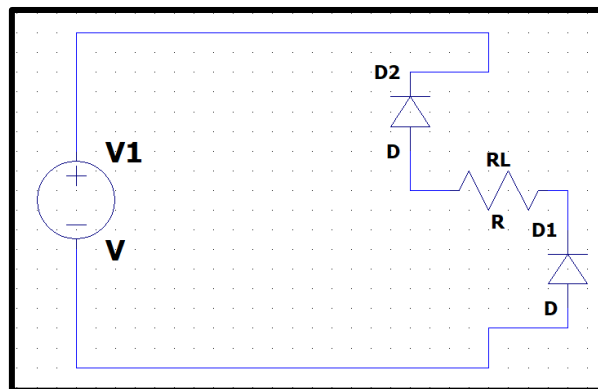


Operation of the Bridge Rectifier:

The circuit consists of four diodes arranged in a bridge. The AC input is connected across two opposite corners of the bridge, while the load resistor is placed between the other two corners.

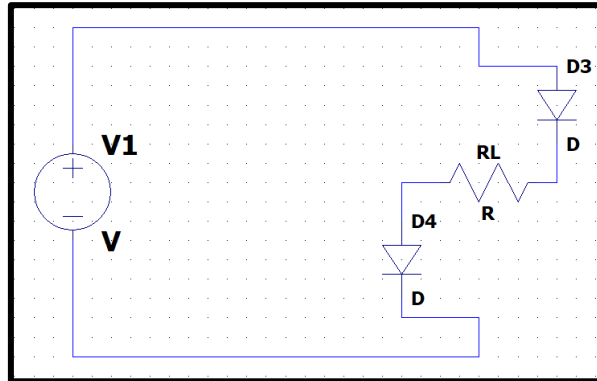
- **Case 1: $V_{in} < 0$**

In this condition, diodes D1 and D2 conduct, while D3 and D4 remain off. The current path is established through the load in such a way that the output voltage is the inverted version of the input, i.e., **$V_{out} = -V_{in}$** (as shown in Figure 3).



- **Case 2: $V_{in} > 0$**

Here, diodes D3 and D4 conduct, while D1 and D2 are cut off. The circuit is reduced to the configuration shown in Figure 4, and the voltage across the load follows the input directly, giving **$V_{out} = V_{in}$** .



Thus, regardless of the input polarity, the output across the load always remains positive, producing a full-wave rectified signal.

The basic parameters of the full wave rectifier circuit are:

For the input:

Average Value:

$$\begin{aligned}
 V_{dc_{avr}} &= \frac{1}{T} \int_0^T v(t) dt = \frac{1}{2\pi} \int_0^{2\pi} V_m \sin \theta d\theta \\
 &= \frac{V_m}{2\pi} [-\cos \theta] = \frac{-V_m}{2\pi} [\cos 2\pi - \cos 0] \\
 &= \frac{-V_m}{2\pi} [1 - 1] = 0
 \end{aligned}$$

RMS Value (effective value):

$$\begin{aligned} V_{rms} &= \sqrt{\frac{1}{T} \int_0^T v(t)^2 dt} \\ &= \sqrt{\frac{1}{2\pi} \int_0^{2\pi} (V_m \sin \theta)^2 d\theta} = \sqrt{\frac{V_m^2}{2\pi} \int_0^{2\pi} \sin^2 \theta d\theta} \\ &= \sqrt{\frac{V_m^2}{2\pi} \int_0^{2\pi} \frac{1}{2} (1 - \cos 2\theta) d\theta} = \sqrt{\frac{V_m^2}{2\pi} \left[\frac{1}{2} \left(\theta - \frac{\sin 2\theta}{2} \right) \right]} \\ &= \sqrt{\frac{V_m^2}{2\pi} \left[\frac{1}{2} \left(2\pi - \frac{\sin 4\pi}{2} \right) - \frac{1}{2} \left(0 - \frac{\sin 0}{2} \right) \right]} = \sqrt{\frac{V_m^2}{2\pi} [\pi]} \\ V_{rms} &= \frac{V_m}{\sqrt{2}} \end{aligned}$$

For the output:

Average value:

$$\begin{aligned} V_{dc_{avr}} &= \frac{1}{T} \int_0^T v(t) dt = \frac{1}{\pi} \int_0^{\pi} V_m \sin \theta d\theta \\ &= \frac{V_m}{\pi} [-\cos \theta] = \frac{-V_m}{\pi} [\cos \pi - \cos 0] \\ &= \frac{-V_m}{2\pi} [-1 - 1] = \frac{2V_m}{\pi} \end{aligned}$$

RMS Value (effective value):

$$\begin{aligned}
 V_{rms} &= \sqrt{\frac{1}{T} \int_0^T v(t)^2 dt} \\
 &= \sqrt{\frac{1}{\pi} \int_0^\pi (V_m \sin \theta)^2 d\theta} = \sqrt{\frac{V_m^2}{\pi} \int_0^\pi \sin^2 \theta d\theta} \\
 &= \sqrt{\frac{V_m^2}{\pi} \int_0^\pi \frac{1}{2} (1 - \cos 2\theta) d\theta} = \sqrt{\frac{V_m^2}{\pi} \left[\frac{\theta}{2} - \frac{\sin 2\theta}{2} \right]} \\
 &= \sqrt{\frac{V_m^2}{\pi} \left[\frac{1}{2} \left(\pi - \frac{\sin 2\pi}{2} \right) - \frac{1}{2} \left(0 - \frac{\sin 0}{2} \right) \right]} = \sqrt{\frac{V_m^2}{2\pi} \left[\pi \right]} \\
 V_{rms} &= \frac{V_m}{\sqrt{2}}
 \end{aligned}$$

Table1 Basic parameter of the FWR

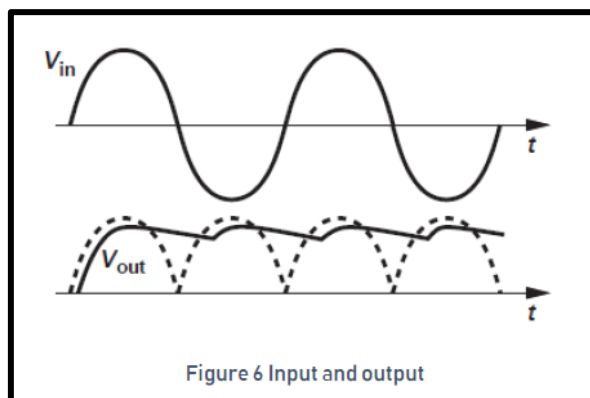
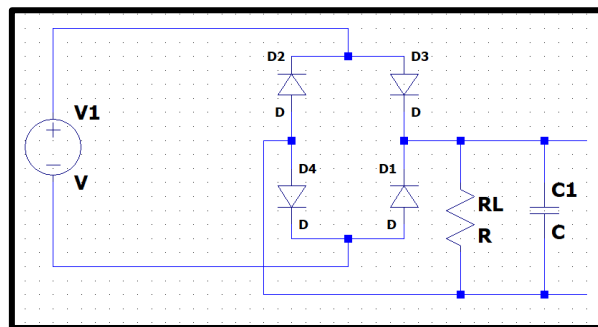
FWR	V(avg)	V(rms)
Input	0	$\frac{V_m}{\sqrt{2}}$
Output	$\frac{2V_m}{\pi}$	$\frac{V_m}{\sqrt{2}}$

Full wave rectifier using a capacitor in shunt as a filter:

In the earlier discussion, we observed that a single-phase half-wave rectifier delivers an output only during one half of each cycle, making it unsuitable for generating a stable DC supply. In contrast, the full-wave bridge rectifier provides a higher average DC voltage with reduced ripple, as it produces an output at twice the frequency of the AC input.

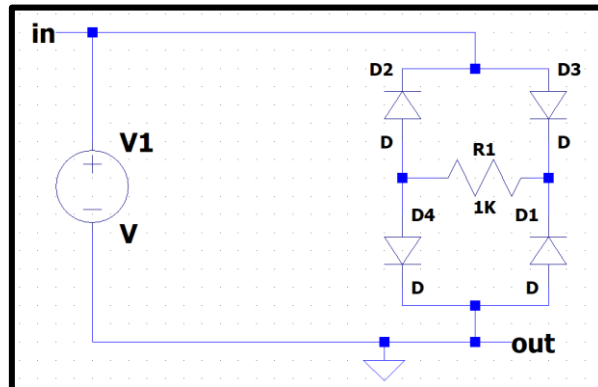
To further enhance the rectifier's performance, smoothing capacitors can be connected in parallel with the load. These capacitors serve as energy storage elements, reducing fluctuations in the rectified output and increasing the effective DC level. As illustrated in Figure 5, the capacitor

charges during the conduction period and discharges slowly through the load, resulting in a smoother and more stable DC output.

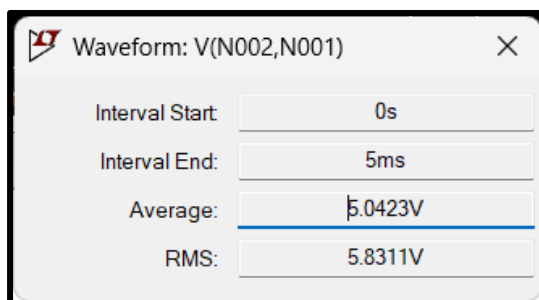
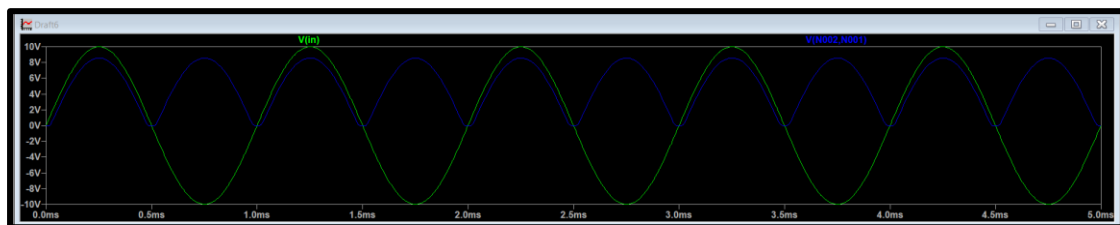


Experiment Procedure:

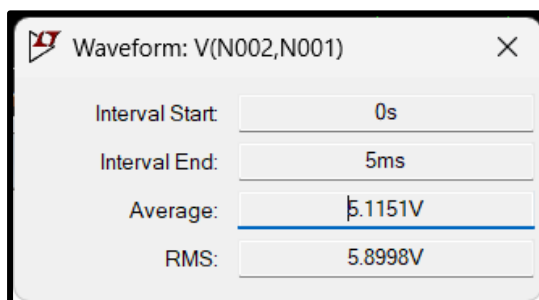
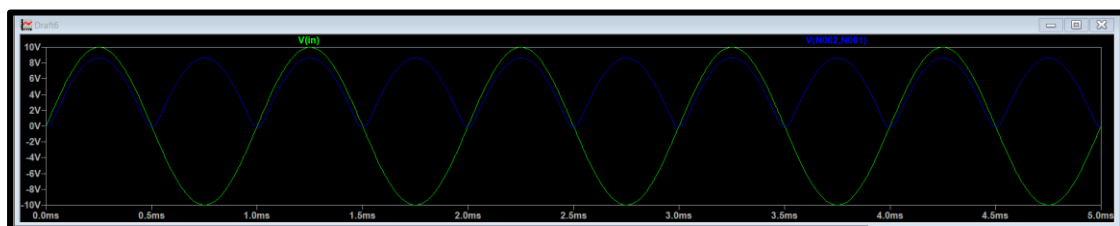
Part 1: FWR with resistive load



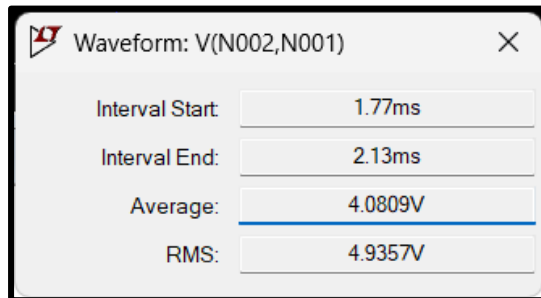
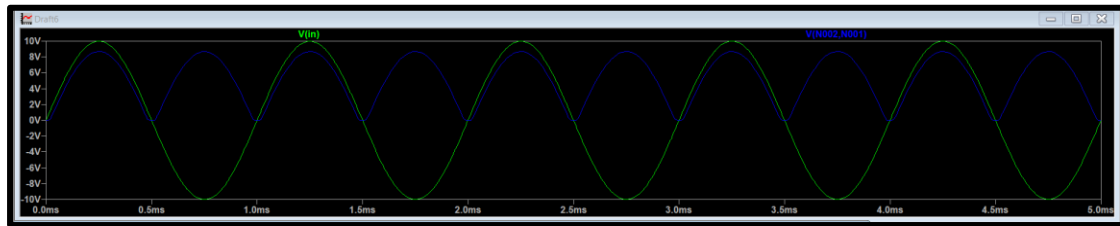
When R and frequency equals 1K



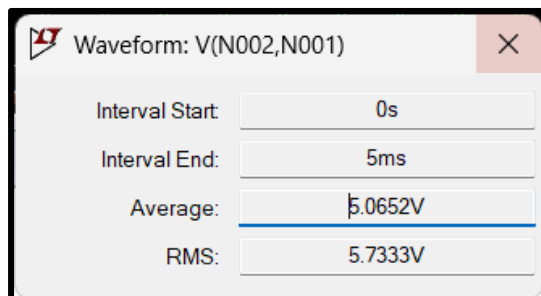
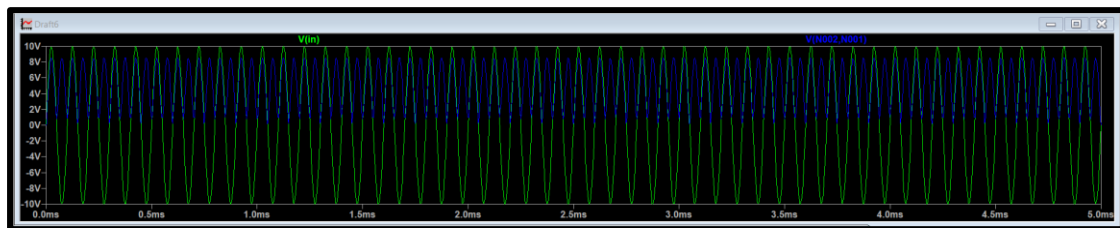
When R = 4.7K Ohm and frequency = 1KHz:



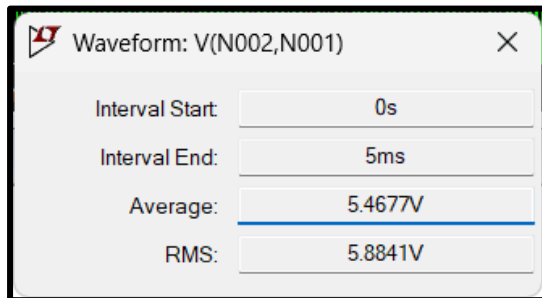
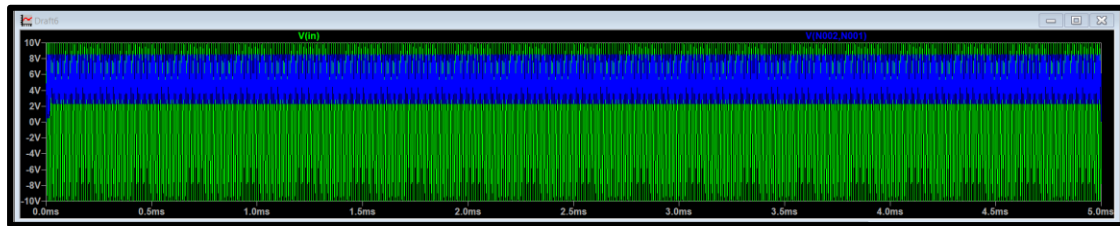
When $R = 10\text{K Ohm}$ and frequency = 1KHz



When $R = 1\text{K Ohm}$ and frequency = 10KHz



When $R = 1\text{K Ohm}$ and frequency = 100KHz

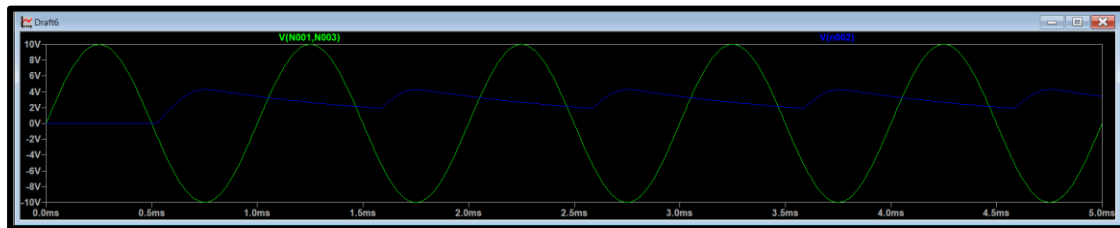
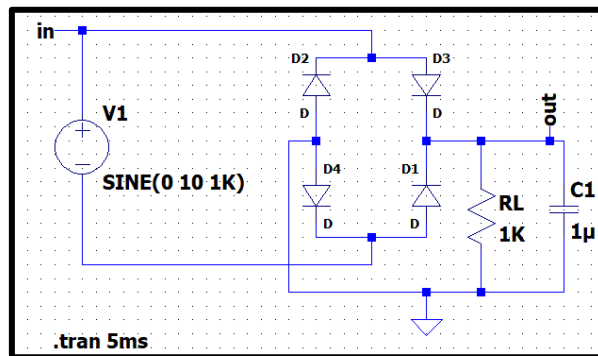


So

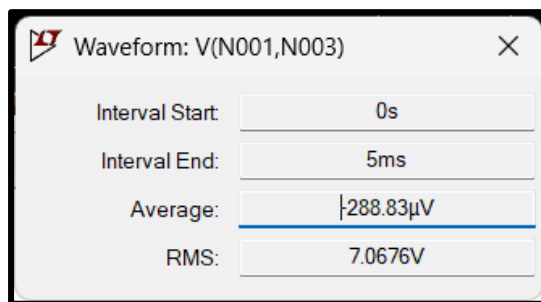
R(K Ohm)	V _{DC} (V)	V _{RMS} (V)
1	5.0423	5.8311
4.7	5.1151	5.8998
10	4.0809	4.9357

f(KHz)	V _{DC} (V)	V _{RMS} (V)
1	5.0423	5.8311
10	5.0652	5.7333
100	5.4677	5.8841

Part 2: FWR with Capacitor load:



V_{input}



V_{output}

