



The Islamic University of Gaza

Faculty of Engineering

Department of Computer Engineering

Electronics I LAB

[LAB 03]

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Objectives

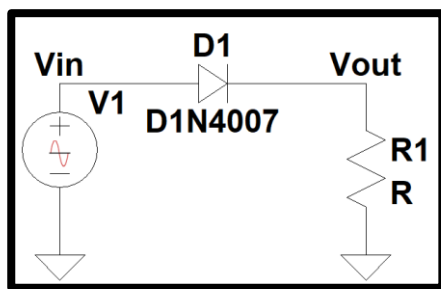
1. To construct a half-wave rectifier circuit and analyze its output.
2. To analyze the rectifier output using a capacitor in shunt as a filter.
3. To be familiar how can be simulate half-wave-rectifier circuit using ltspice simulation.

Equipment

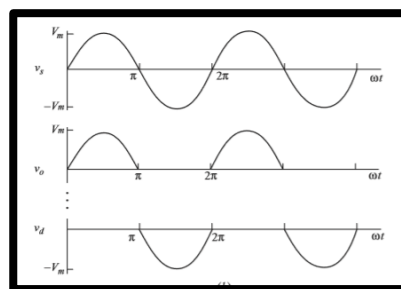
- Diode (1N4007).
- Resistors.
- Function generator.
- Oscilloscope.

Theory

The process of converting an alternating current into direct current is known as rectification. The unidirectional conduction property of semiconductor diodes (junction diodes) is used for rectification. Rectifiers are of two types: (a) Half wave rectifier and (b) Full wave rectifier. In this lab we will discuss a half wave rectifier circuit as shown in Figure (a), during the positive half-cycle of the input, the diode is forward biased and conducts. Current flows through the load and a voltage is developed across it. During the negative half-cycle, it is reverse bias and does not conduct. Therefore, in the negative half cycle of the supply, no current flows in the load resistor as no voltage appears across it. Thus, the dc voltage across the load is sinusoidal for the first half cycle only and a pure AC. input signal is converted into a unidirectional pulsating output signal.



(a)



(b)

The basic parameters of the half wave rectifier circuit are:

For the input:

✚ Average Value:

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

✚ RMS Value:

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

For the output:

✚ Average Value:

$$V_{dc_{avg}} = \frac{1}{T} \int_0^T v(t) dt = \frac{1}{2\pi} \int_0^{\pi} V_m \sin \theta d\theta + \int_{\pi}^{2\pi} 0 d\theta$$
$$= \frac{V_m}{2\pi} [-\cos \theta] + 0 = \frac{-V_m}{2\pi} [\cos \pi - \cos 0] = \frac{-V_m}{2\pi} [-1 - 1] = \frac{V_m}{\pi}$$

✚ RMS Value

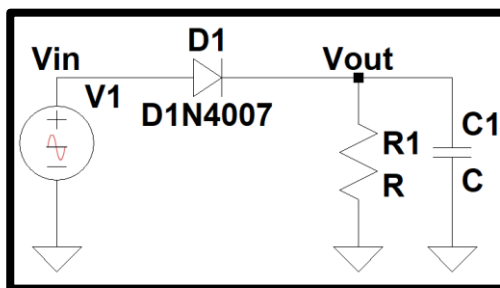
$$\begin{aligned}
 V_{rms} &= \sqrt{\frac{1}{T} \int_0^T v(t)^2 dt} = \sqrt{\frac{1}{2\pi} \int_0^\pi (V_m \sin \theta)^2 d\theta} = \sqrt{\frac{V_m^2}{2\pi} \int_0^\pi \sin^2(\theta) d\theta} \\
 &= \sqrt{\frac{V_m^2}{2\pi} \int_0^\pi \frac{1}{2} (1 - \cos 2\theta) d\theta} = \sqrt{\frac{V_m^2}{2\pi}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

So, the summary for these operations as shown:

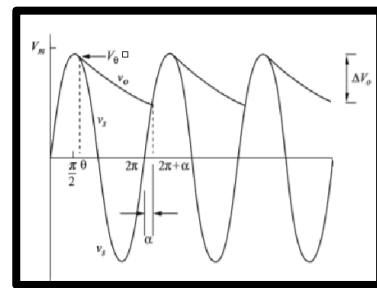
HWR	V_{avg}	V_{rms}
Input	0	$\frac{V_m}{\sqrt{2}}$
Output	$\frac{V_m}{\pi}$	$\frac{V_m}{2}$

Rectifier output using a capacitor in shunt as a filter:

The output of a rectifier gives a pulsating DC signal as shown in Figure a and Figure b, because of presence of some AC. components whose frequency is equal to that of the AC supply frequency. Very often when rectifying an alternating voltage, we wish to produce a "steady" direct voltage free from any voltage variations or ripple. Filter circuits are used to smoothen the output. Various filter circuits are available such as shunt capacitor, series inductor. Here we will use a simple shunt capacitor filter circuit as shown in Figure3. Since a capacitor is open to DC and offers low impedance path to AC current, putting a capacitor across the output will make the DC component to pass through the load resulting in small ripple voltage.



(a)

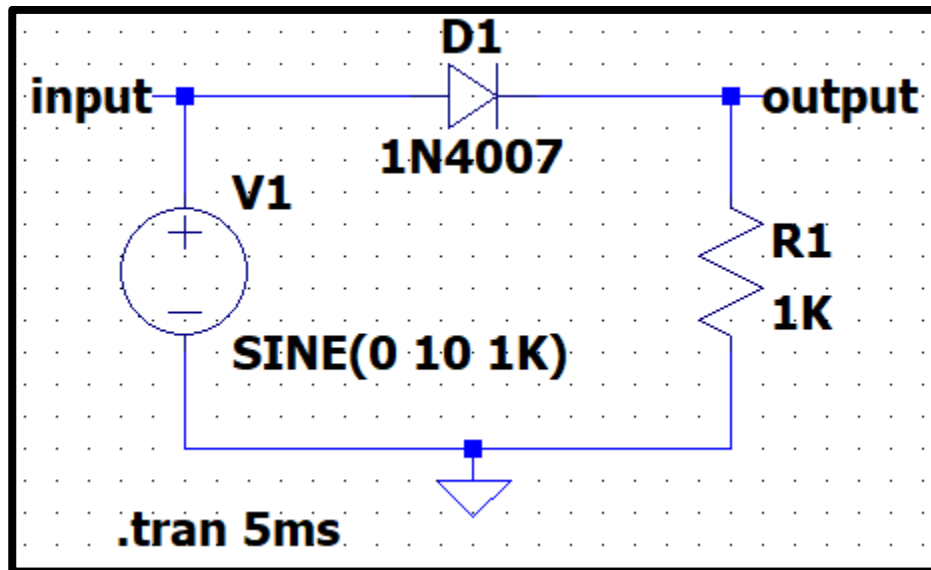


(b)

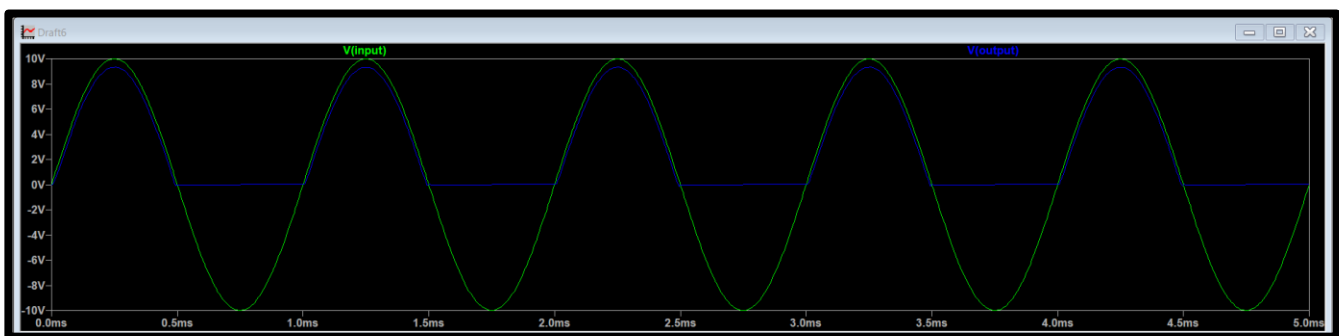
The working of the capacitor can be understood in the following manner. When the rectifier input voltage is increasing, the capacitor charges to the peak voltage V_m . Just past the positive peak the rectifier output voltage tries to fall. As the source voltage decreases below V_m , the capacitor will try to send the current back to diode making it reverse biased. Thus the diode separates/disconnects the source from the load and hence the capacitor will discharge through the load until the source voltage becomes more than the capacitor voltage. The diode again starts conducting and the capacitor is again charged to the peak value V_m and the process continues.

Experiment Procedure

Part01: HWR with resistive load



input and output voltage using oscilloscope.



Now we will find V_{DC} and V_{RMS} , with constant frequency = 1KHz, on resistors: 1K Ω , 4.7K Ω and 10K Ω

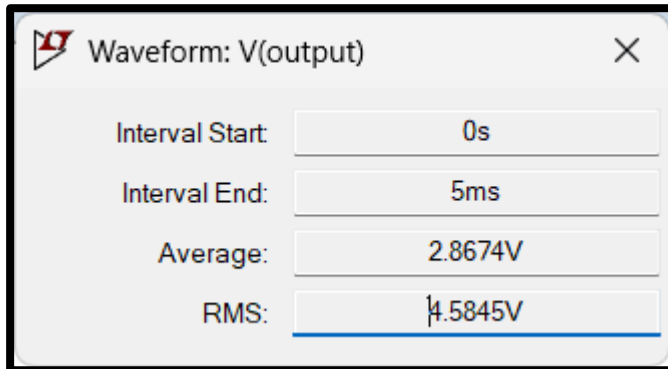
$R(K\Omega)$	$V_{DC}(V)$	$V_{rms}(V)$
1	2.8674	4.5845
4.7	2.8946	4.62
10	2.9079	4.6374

And here we will find V_{DC} and V_{RMS} , with constant resistor: 1K Ω , on frequencies: 1KHz, 10KHz and 100KHz

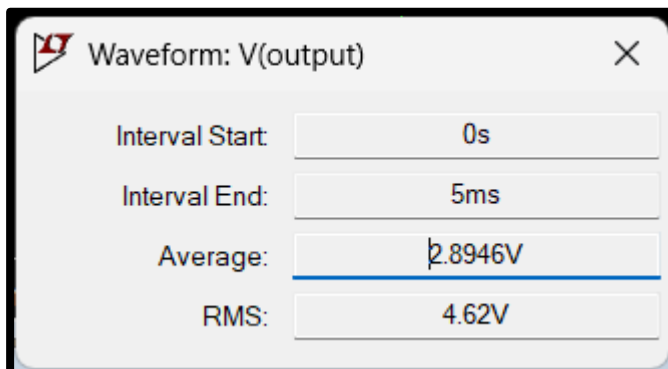
$f(KHz)$	$V_{DC}(V)$	$V_{rms}(V)$
1	2.8674	4.5845
10	2.7746	4.5139
100	1.502	5.4719

And this is the pictures of the results from LTSpice:

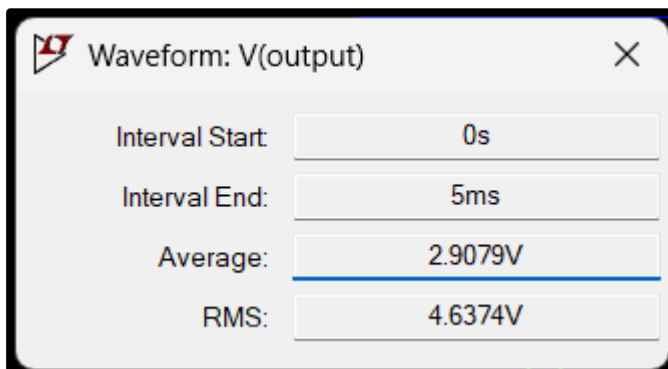
When R and frequency = 1K



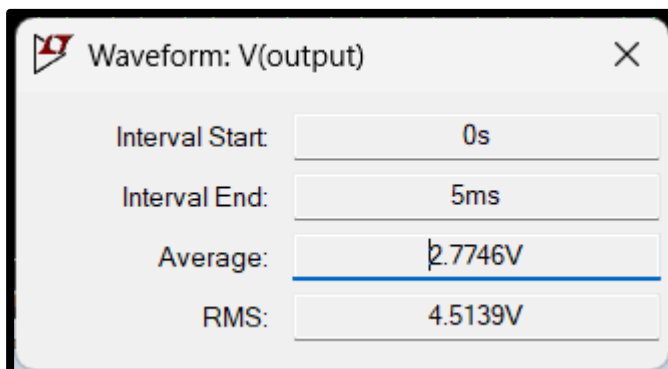
When R = 4.7K and frequency = 1K



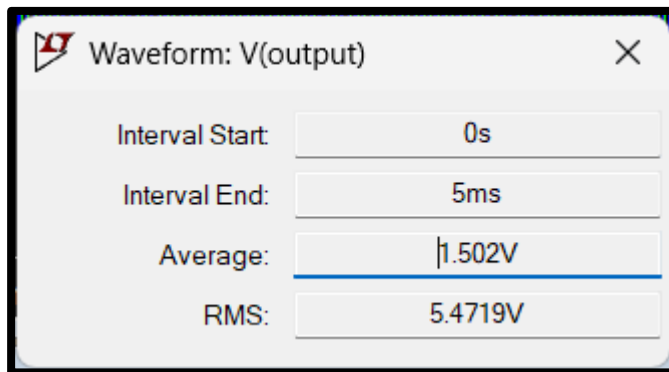
When R = 10K and frequency = 1K



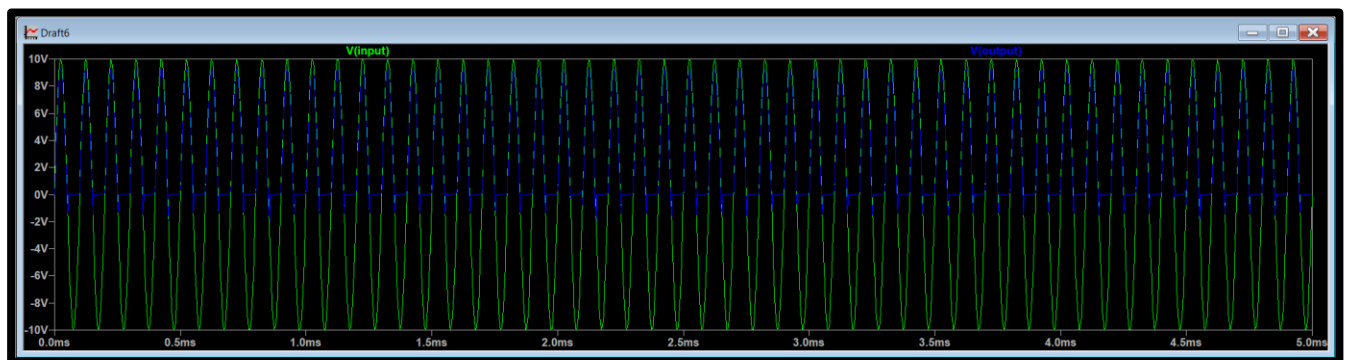
When R = 1K and frequency = 10K



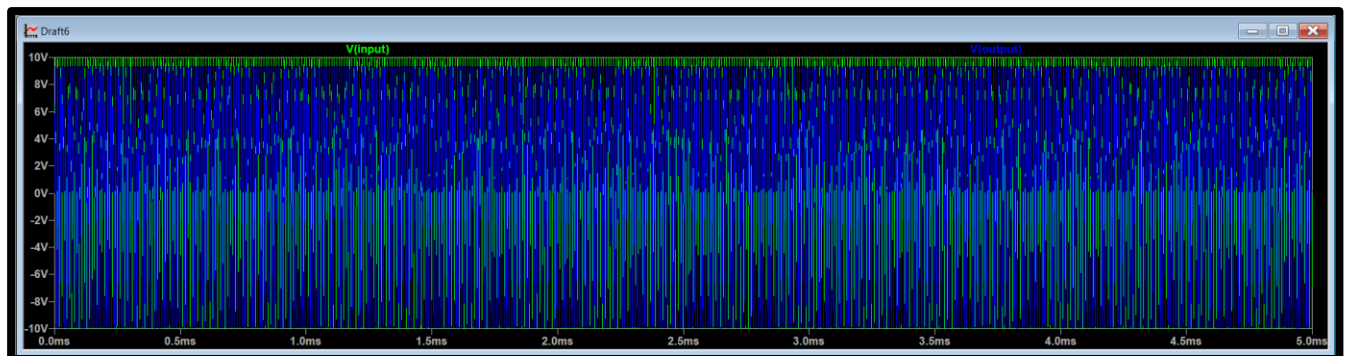
When $R = 1K$ and frequency = 100K



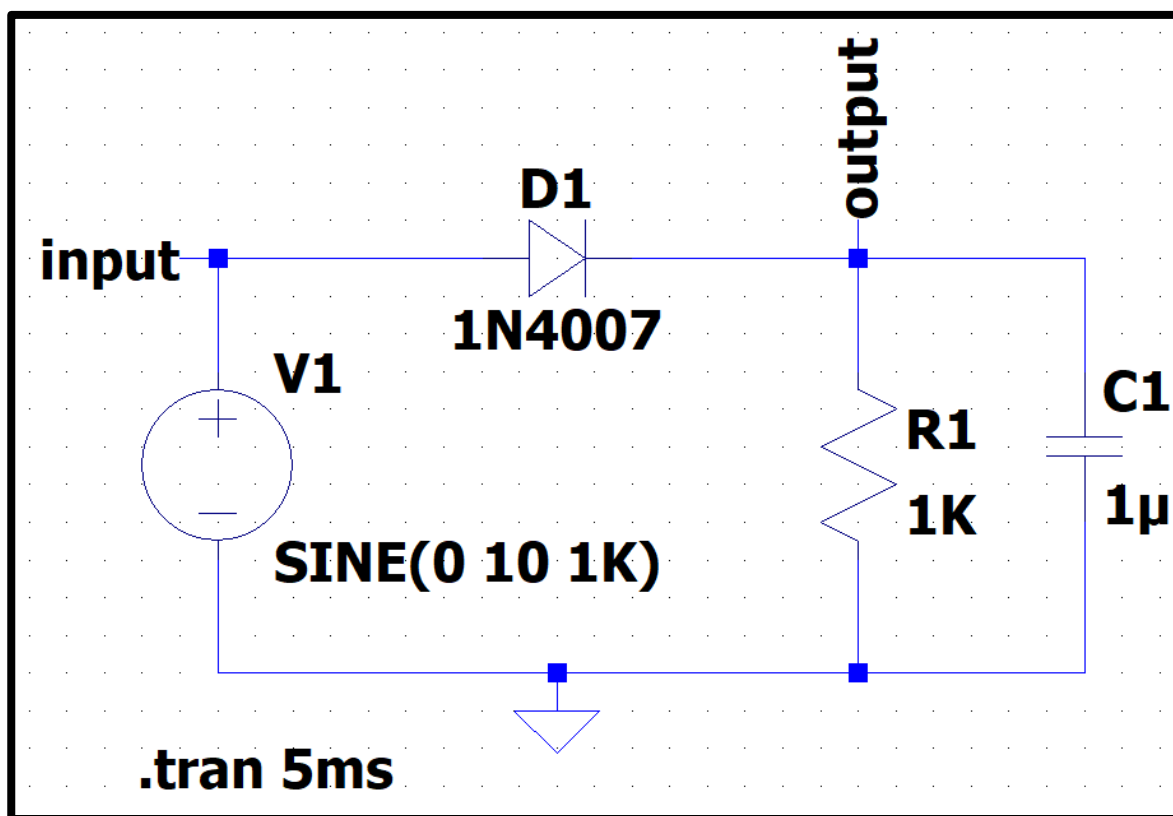
And there is input and output voltage using oscilloscope.
When $R = 1K$ and frequency = 10K



When $R = 1K$ and frequency = 100K



Part02: HWR with capacitive load



input and output voltage using oscilloscope.

