Aim ↬ To plot the output waveform of the Half Wave Rectifier and also calculate the ripple factor and efficiency of the rectifier with and without filter.

Equipment Required ↬

Transformer, Diode, Resistance, Capacitance, Power supply, CRO, Breadboard, and connecting wires.

Theory ↬

A half-wave rectifier is a fundamental type of rectifier used to convert alternating current (AC) into direct current (DC). In this rectification process, the diode allows current to pass only during the positive half-cycles of the AC input signal, blocking the negative half-cycles, which results in a pulsating DC output. The output waveform of a half-wave rectifier is characterized by having a series of positive pulses corresponding to the positive half-cycles of the input AC signal, while the negative half-cycles are suppressed.

When a filter (typically a capacitor) is added to the rectifier circuit, it smooths out the pulsations by storing charge during the peak voltage and releasing it during the intervals when the input voltage drops, thus reducing the fluctuations in the output voltage. This results in a smoother DC output waveform.

The effectiveness of the smoothing is often quantified by the ripple factor, which is the ratio of the root mean square (RMS) value of the AC component to the DC component in the output. The ripple factor for a half-wave rectifier without a filter is relatively high, while the addition of a filter significantly reduces it.

Without Filter -

$$Ripple\ Factor = \gamma = \frac{V_{ac}}{V_{dc}} = \sqrt{(\frac{V_{rms}}{V_{dc}})^2 - 1}$$

where, $V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$

$$V_{rms} = \frac{V_m}{2}$$

$$V_{dc} = \frac{V_m}{\pi}$$

With Filter -

$$Ripple\ Factor = \gamma = \frac{1}{2\sqrt{3} f R_L C}$$

Efficiency of a rectifier is defined as the ratio of the DC power delivered to the load to the AC power input from the source. For a half-wave rectifier, the efficiency is inherently lower than other rectification methods like full-wave rectification due to the fact that it only utilizes one half of the input signal. The theoretical maximum efficiency of a half-wave rectifier is approximately 40.6%. When a filter is added, while the output becomes smoother, the efficiency may slightly improve due to reduced ripple losses but it is primarily intended to enhance the quality of the DC output rather than significantly boost efficiency.

$$\eta = \frac{P_{DC}}{P_{AC}} \times 100\%$$

where, $P_{AC} = \frac{{V_{rms}}^2}{R_L}$

$P_{DC} = \frac{{V_{dc}}^2}{R_L}$

In summary, a half-wave rectifier converts AC to pulsating DC by passing only the positive half-cycles through a diode. Adding a filter smooths the output, reducing the ripple factor.

Circuit Diagram ↬

- **Half Wave Rectifier without Filter ↪**

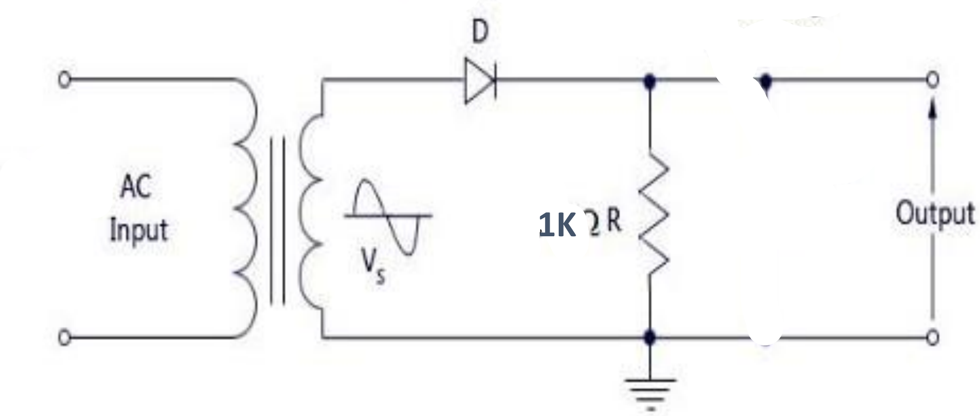

Fig 1. Half Wave Rectifier without Filter

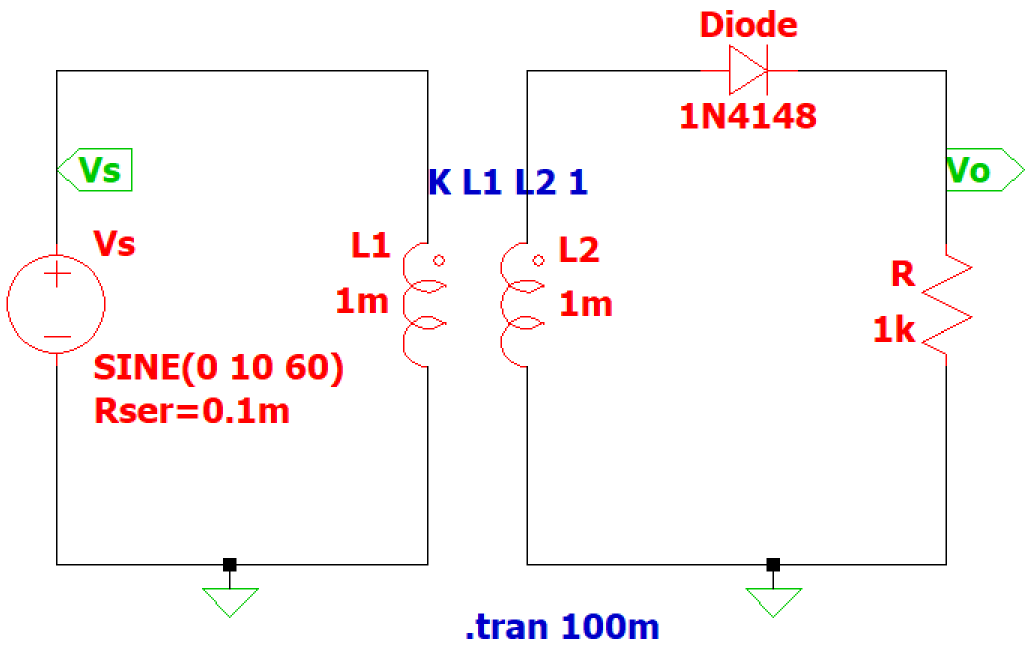

Fig 2. Circuit in LTSpice

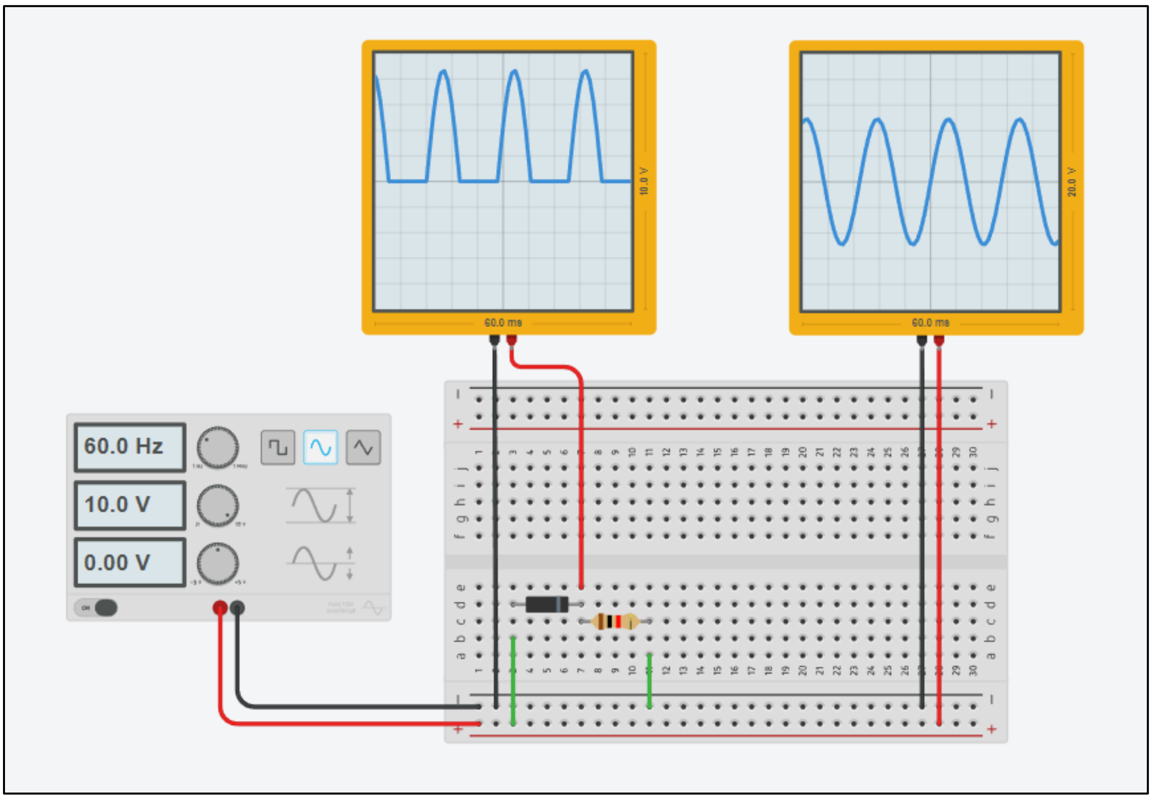

Fig 3. Circuit in TinkerCad

➢ **Half Wave Rectifier with Filter ↪**

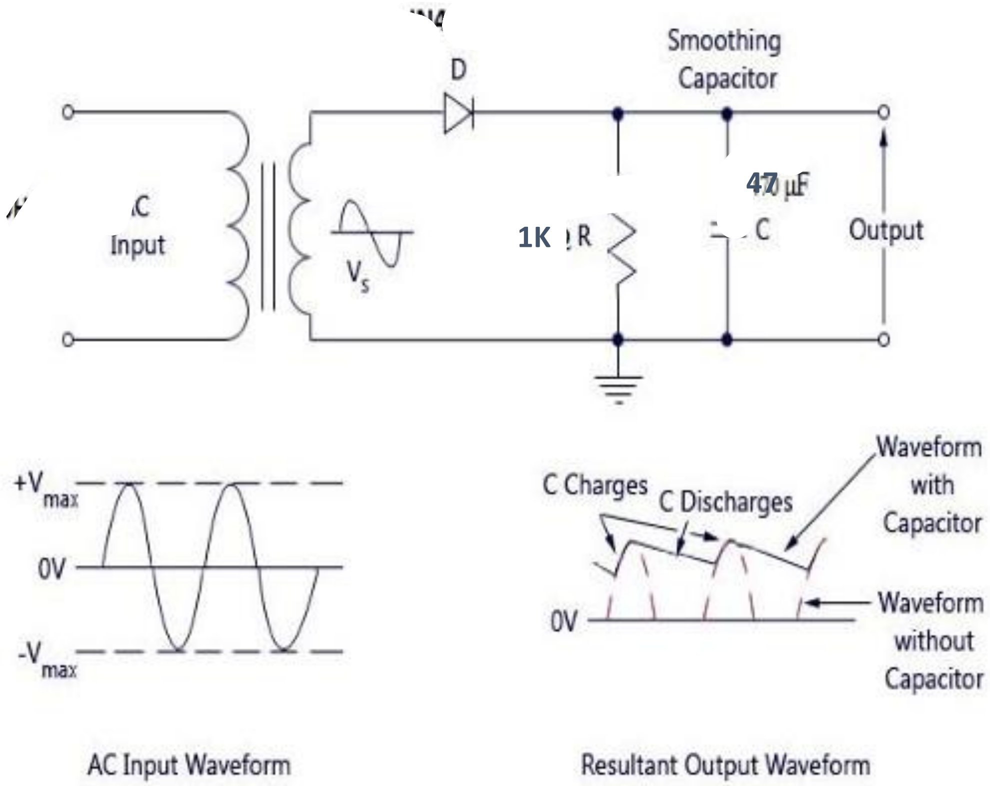

Fig 4. Half Wave Rectifier with Filter

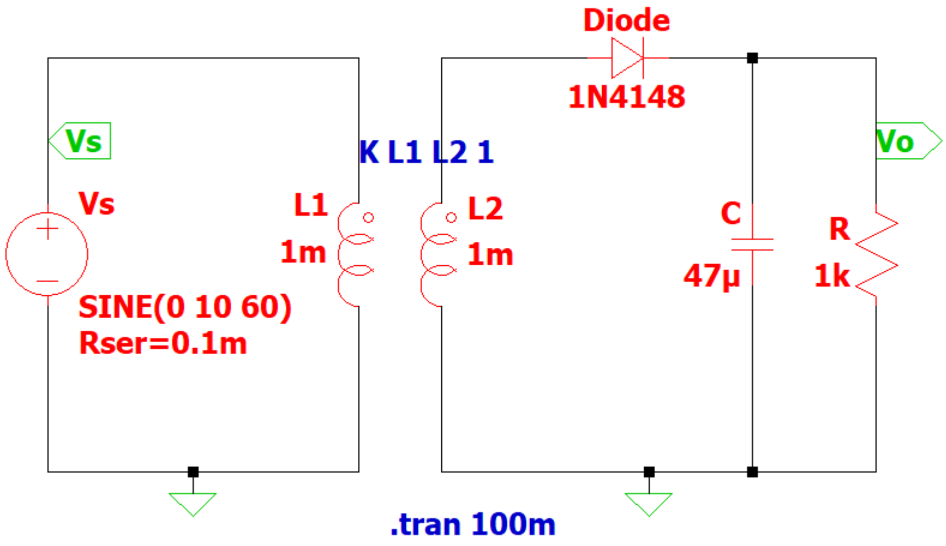

Fig 5. Circuit in LTSpice

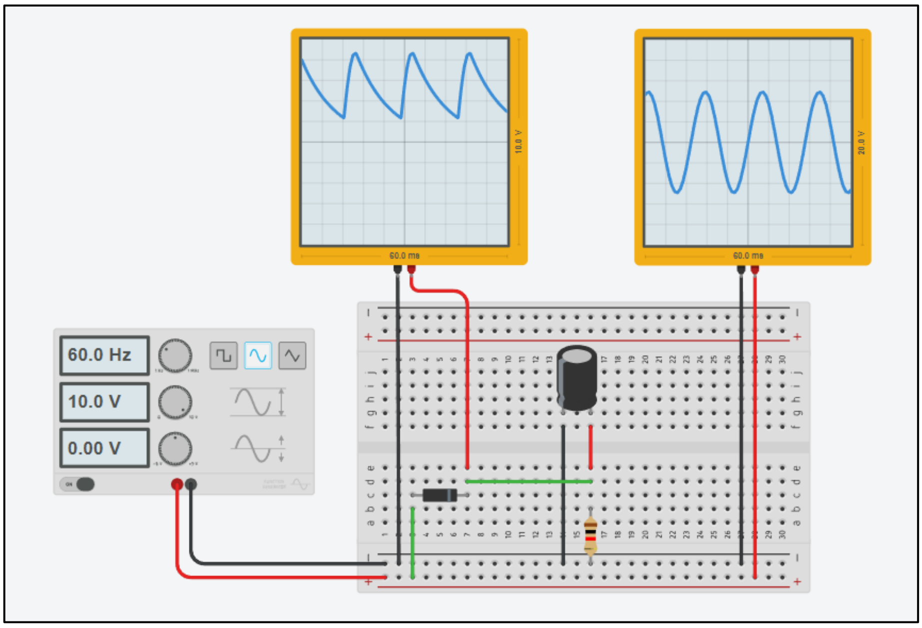

Fig 6. Circuit in TinkerCad

Graphs ↬

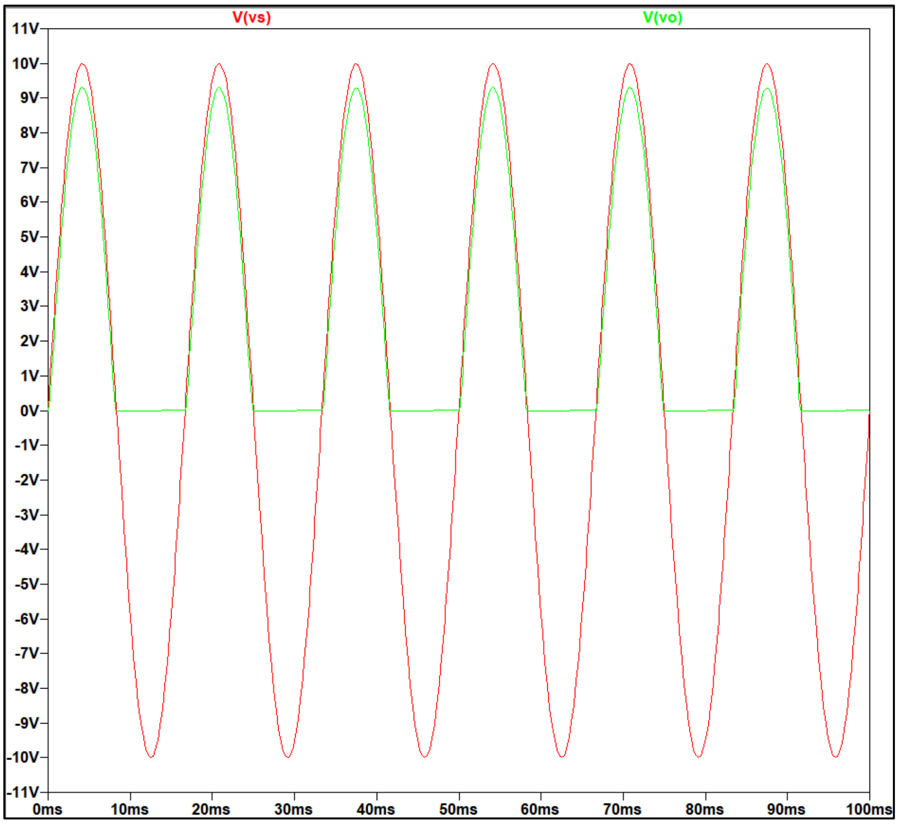

Fig 7. Half Wave Rectifier without Filter

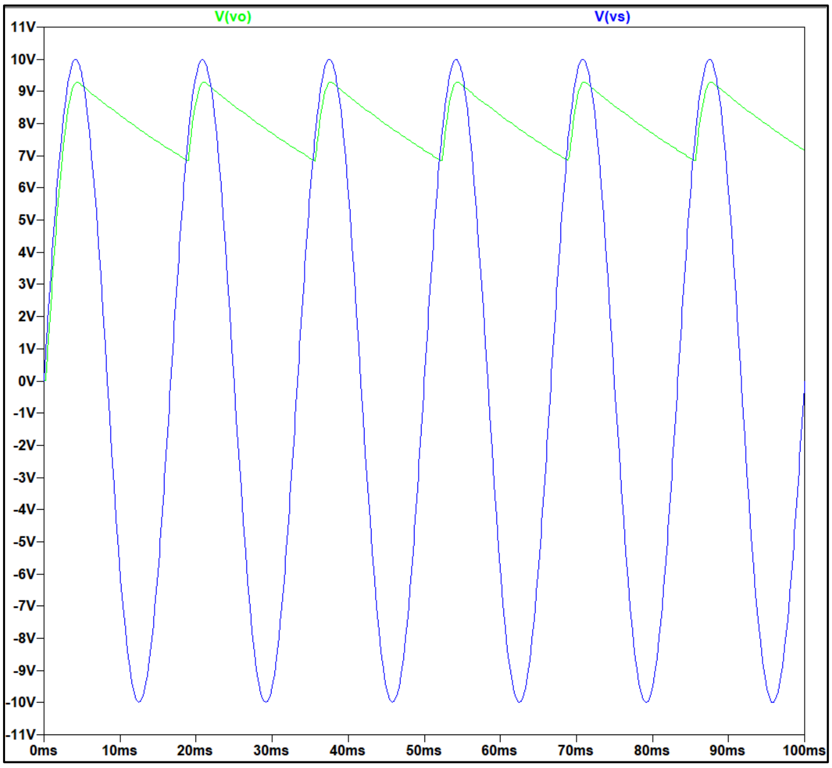

Fig 8. Half Wave Rectifier with Filter

Calculation ↬

- Without Filter ↪

$$Ripple\ Factor = \gamma = \frac{V_{ac}}{V_{dc}} = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$$

Putting values of V_{rms} & V_{dc} –

$$\gamma = \sqrt{\left(\frac{\frac{Vm}{2}}{\frac{Vm}{\pi}}\right)^2 - 1} = \sqrt{\left(\frac{\pi}{2}\right)^2 - 1}$$

$$\boxed{\gamma = 1.21}$$

- With Filter ↪

$$Ripple\ Factor = \gamma = \frac{1}{2\sqrt{3}fR_LC}$$

$$\gamma = \frac{1}{2\sqrt{3} \times 60 \times 10^3 \times 47 \times 10^{-6}}$$

$$\boxed{\gamma = 0.102}$$

Efficiency remains the same in both cases -

$$Efficiency = \eta = \frac{P_{DC}}{P_{AC}} \times 100\%$$

$$\eta = \left(\frac{\frac{\left(\frac{V_m}{\pi}\right)^2}{R_L}}{\frac{\left(\frac{V_m}{2}\right)^2}{R_L}} \right) \times 100\% = \left(\frac{2}{\pi}\right)^2 \times 100\%$$

$$\boxed{\eta = 40.53\%}$$

Result ↬

For a half-wave rectifier without a filter, the ripple factor (RF) is approximately 1.21, and the maximum theoretical efficiency is about 40.6%. When a capacitor filter is added, the ripple factor significantly reduces to around 0.1 or less, while the efficiency remains close to 40.6%, enhancing the quality of the DC output rather than significantly increasing efficiency. These results confirm the effectiveness of filtering in reducing ripple while maintaining the inherent efficiency of the half-wave rectification process.

Conclusion ↬

Successfully performed the experiment and verified the result with the simulation result.

Precautions ↬

- The primary and secondary sides of the transformer should be carefully identified.
- While doing the experiment do not exceed the ratings of the diode. This may lead to damage the diode.
- The polarities of the diode should be carefully identified.
- Do not switch ON the power supply unless you have checked the circuit connections as per the circuit diagram.