Aim ↬ To plot the output waveform of the Full 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 Full-wave rectifier converts alternating current (AC) into direct current (DC) by using both halves of the AC input signal. There are two main types: centre-tap and bridge rectifiers.

- In a centre-tap full-wave rectifier, a centre-tap transformer is used with two diodes. Each diode conducts during alternate half-cycles of the AC input, resulting in both halves of the AC signal being used. The centre-tap of the transformer provides a neutral point, allowing the two halves of the input waveform to be combined into a single, continuous positive output.
- The bridge rectifier uses four diodes in a bridge configuration without needing a centre-tap transformer. During the positive half-cycle, two diodes conduct to pass the positive current through the load, while during the negative half-cycle, the other two diodes conduct to reverse the polarity of the negative half-cycle, thereby converting it to a positive current.

The output waveform of a full-wave rectifier consists of a series of positive pulses that correspond to both the positive and negative half-cycles of the AC input. This results in a pulsating DC output with a frequency that is double that of the input AC signal. When a filter (typically a capacitor) is added to the full-wave rectifier circuit, it further smooths out the pulsations by storing charge during the peak voltage and releasing it during the intervals when the input voltage drops. This significantly reduces the fluctuations in the output voltage, resulting in a much smoother DC output.

The ripple factor quantifies the effectiveness of the smoothing process. It is defined as the ratio of the root mean square (RMS) value of the AC component to the DC component in the output. The ripple factor is lower for a full-wave rectifier than a half-wave rectifier, indicating a smoother DC output even without a filter.

Without Filter -

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

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

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

$$V_{dc} = \frac{2V_m}{\pi}$$

With Filter -

$$Ripple\ Factor = \gamma = \frac{1}{4\sqrt{3}fR_LC}$$

The 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 full-wave rectifier, the efficiency is higher than that of a half-wave rectifier because it utilizes both halves of the input signal. The theoretical maximum efficiency of a full-wave rectifier is approximately 81.2%.

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

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

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

A full-wave rectifier converts AC to pulsating DC by using both the positive and negative half-cycles of the input signal through a configuration of diodes. The addition of a filter smooths the output, significantly reducing the ripple factor. The full-wave rectifier is more efficient than the half-wave rectifier, with a theoretical maximum efficiency of about 81.2%, and it produces a smoother DC output with a lower ripple factor, especially when a filter is used.

Circuit Diagram ↬

- **Full Wave Bridge Rectifier without Filter ↪**

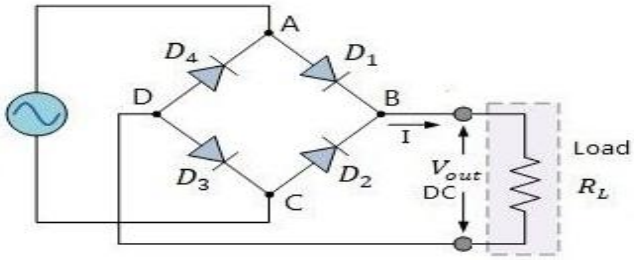

Fig 1. Full Wave Bridge Rectifier without Filter

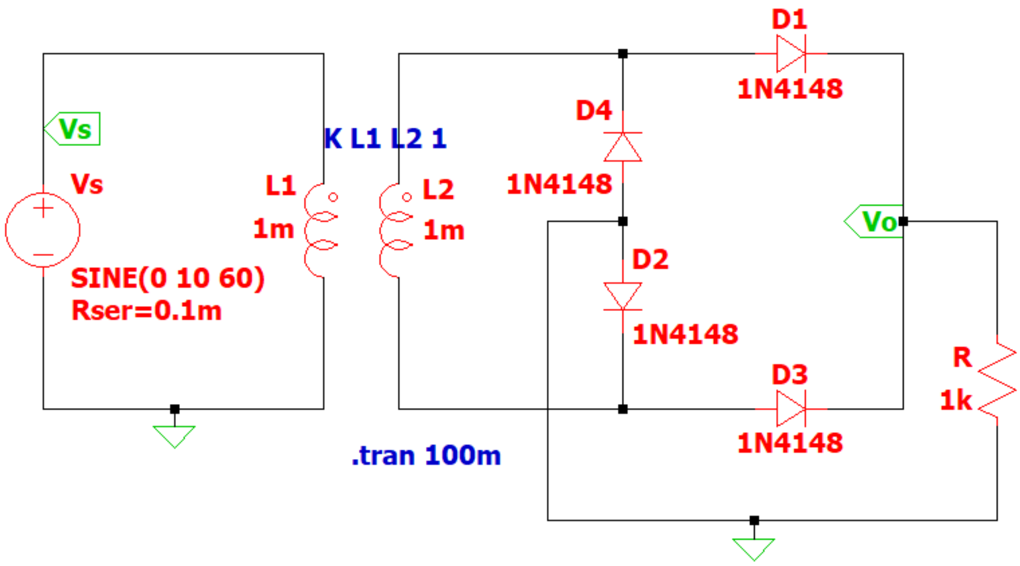

Fig 2. Circuit in LTSpice

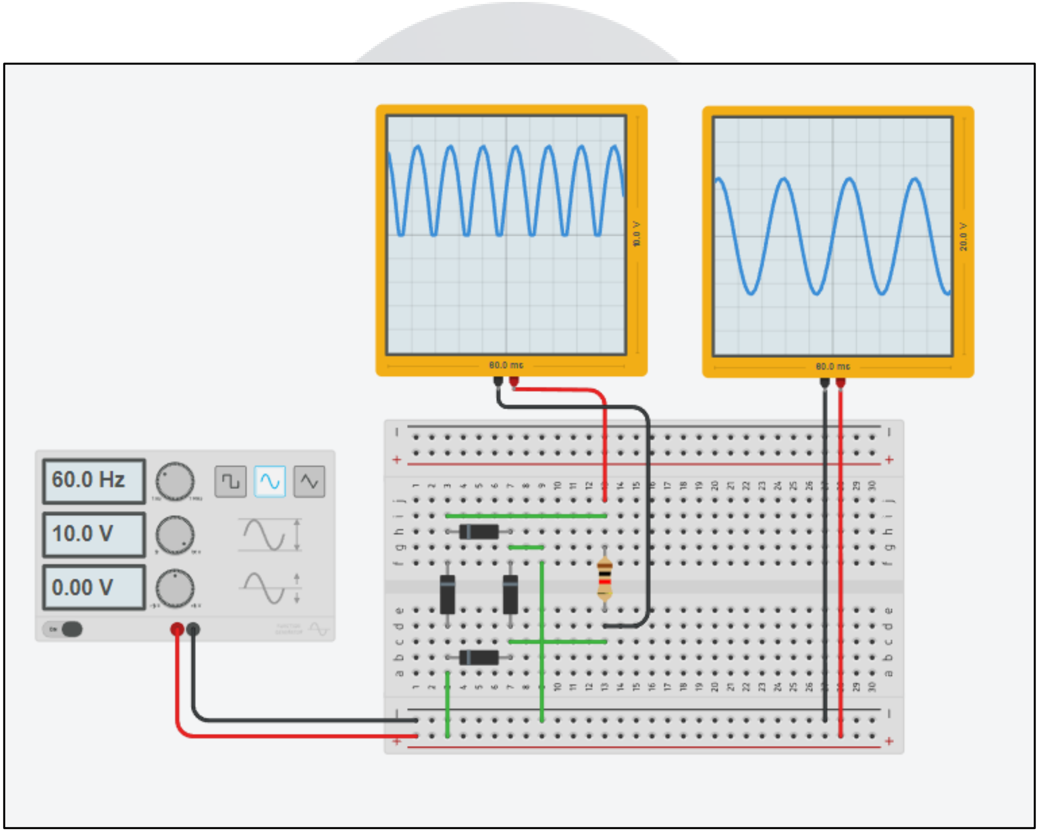

Fig 3. Circuit in TinkerCad

➢ Full Wave Bridge Rectifier with Filter ↪

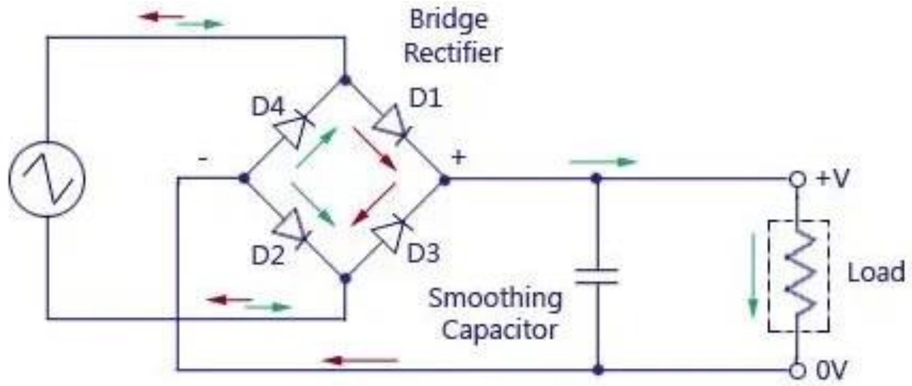

Fig 4. Full Wave Bridge Rectifier with Filter

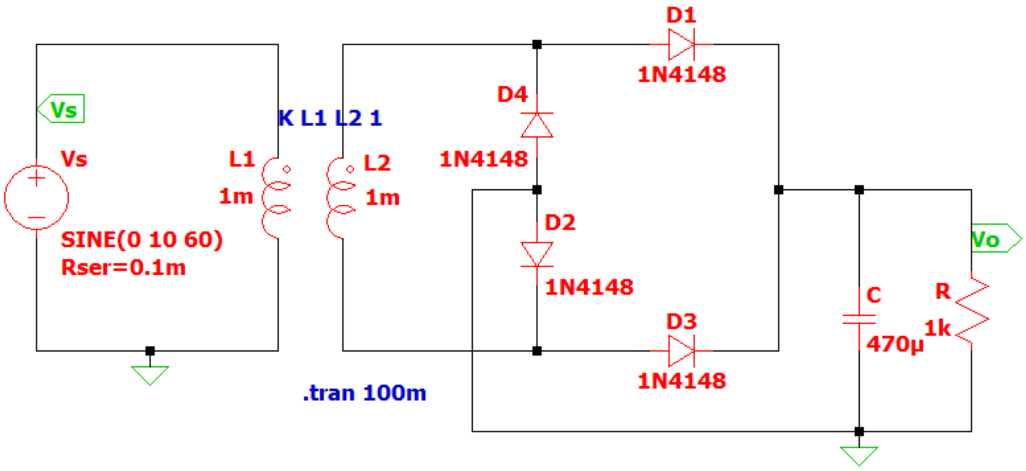

Fig 5. Circuit in LTSpice

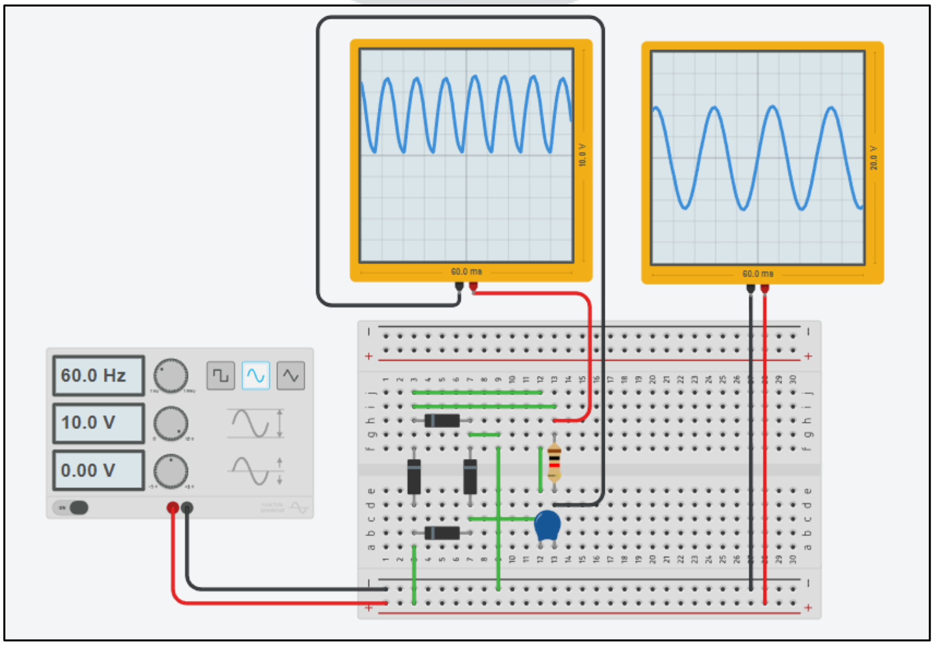

Fig 6. Circuit in TinkerCad

Note – Tinkercad can't process the continuously changing value of voltage; hence, it does not give the actual desired result.

- **Full Wave Centre Tapped Rectifier without Filter ↪**

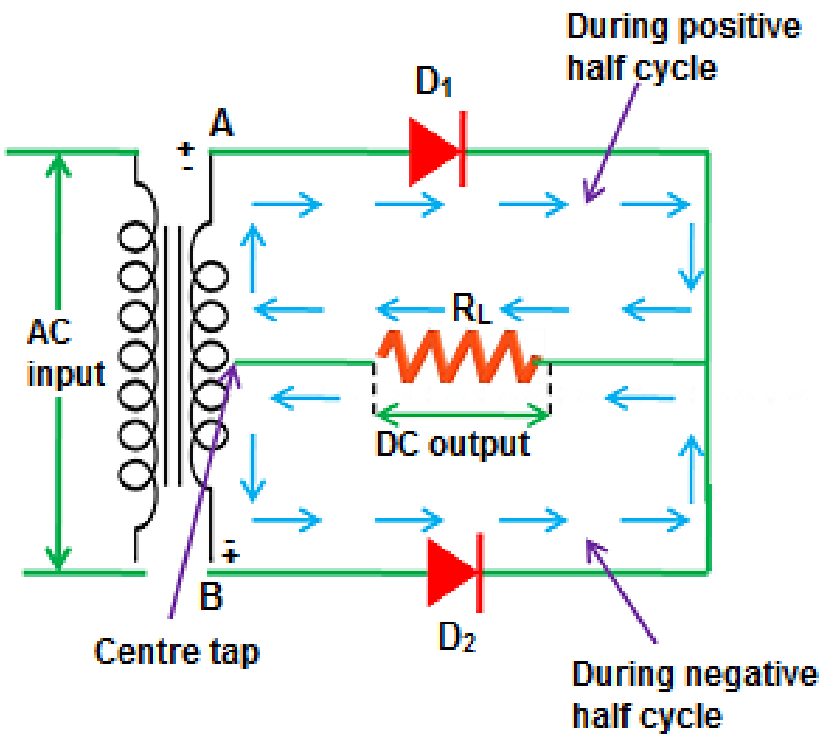

Fig 7. Full Wave Centre Tapped Rectifier without Filter

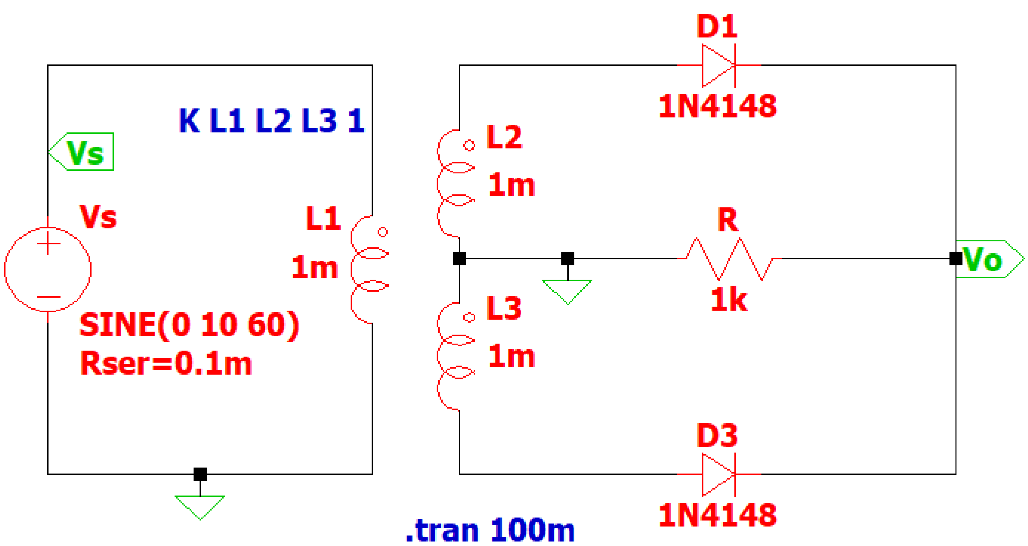

Fig 8. Circuit in LTSpice

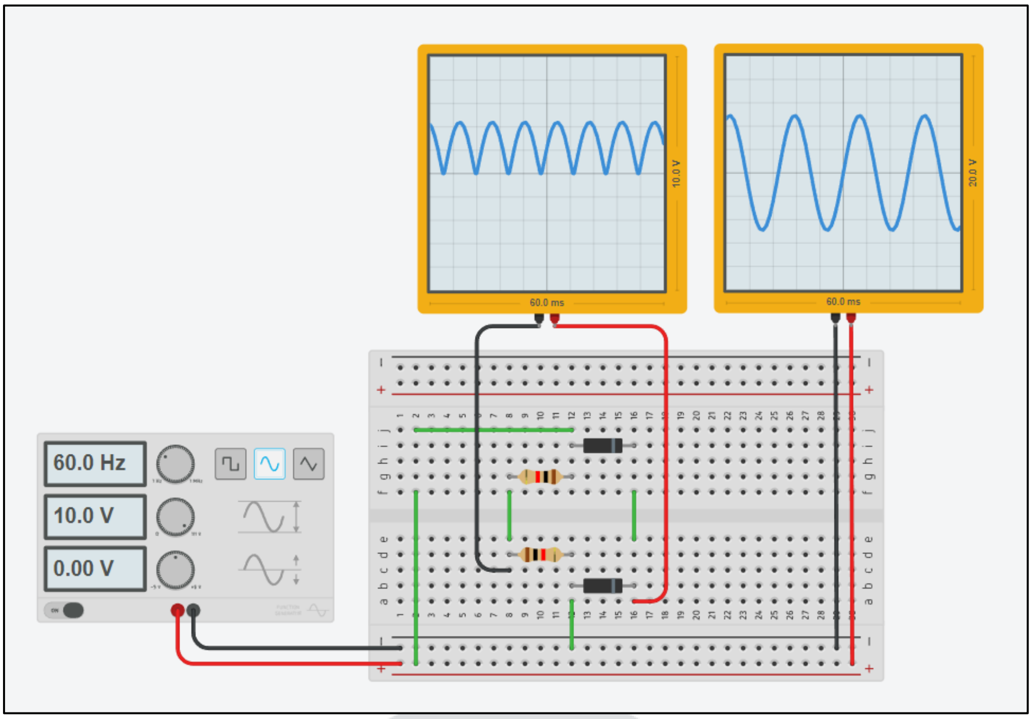

Fig 9. Circuit in TinkerCad

- **Full Wave Centre Tapped Rectifier with Filter ↪**

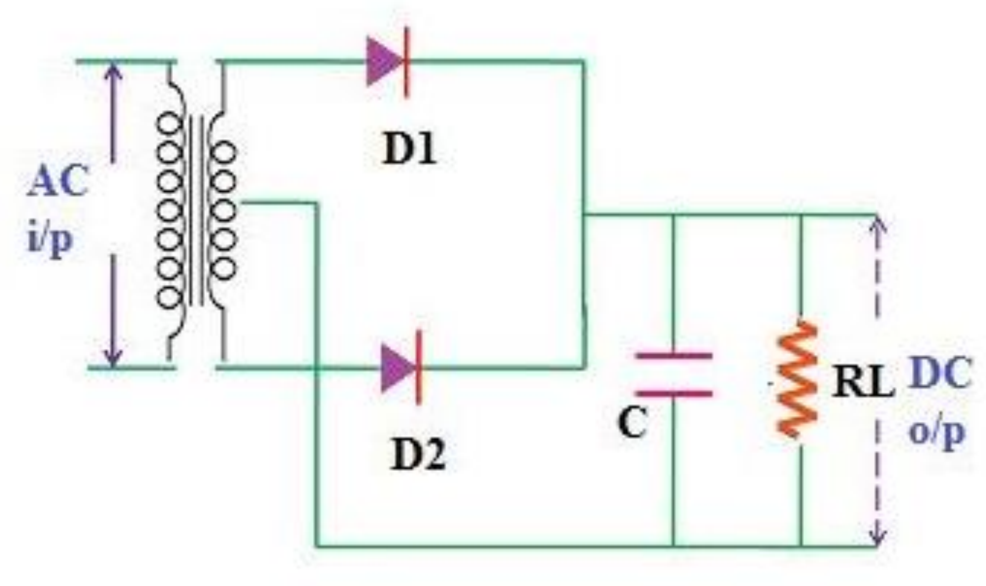

Fig 10. Full Wave Centre Tapped Rectifier with Filter

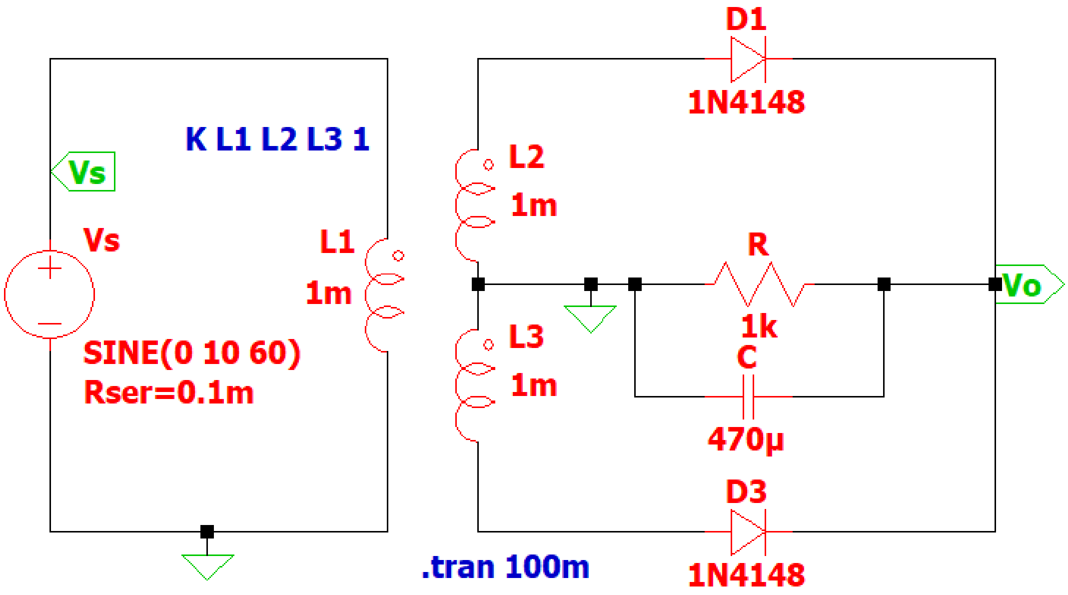

Fig 11. Circuit in LTSpice

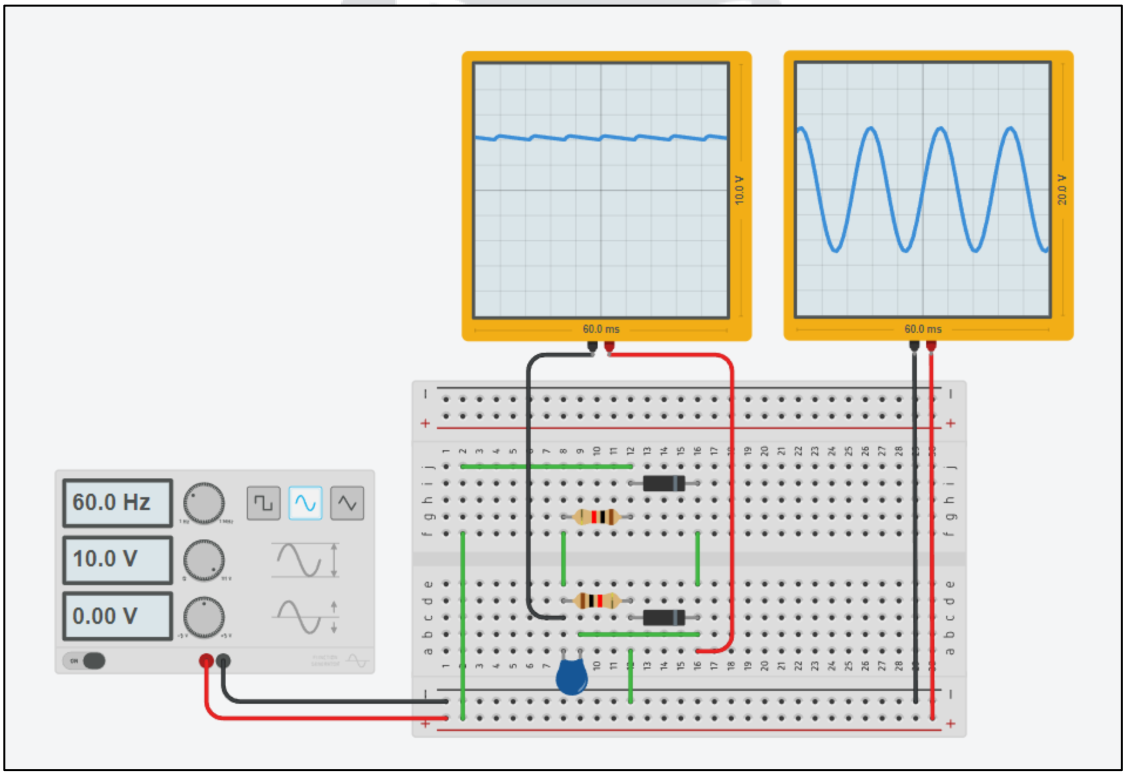

Fig 12. Circuit in TinkerCad

Graphs ↬

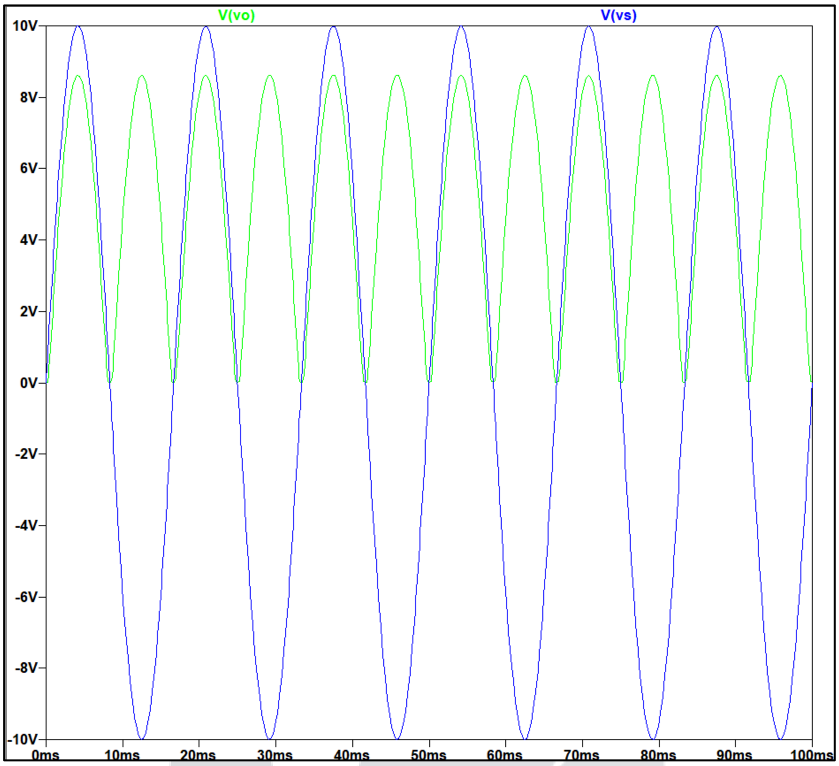

Fig 13. Full Wave Bridge Rectifier without Filter

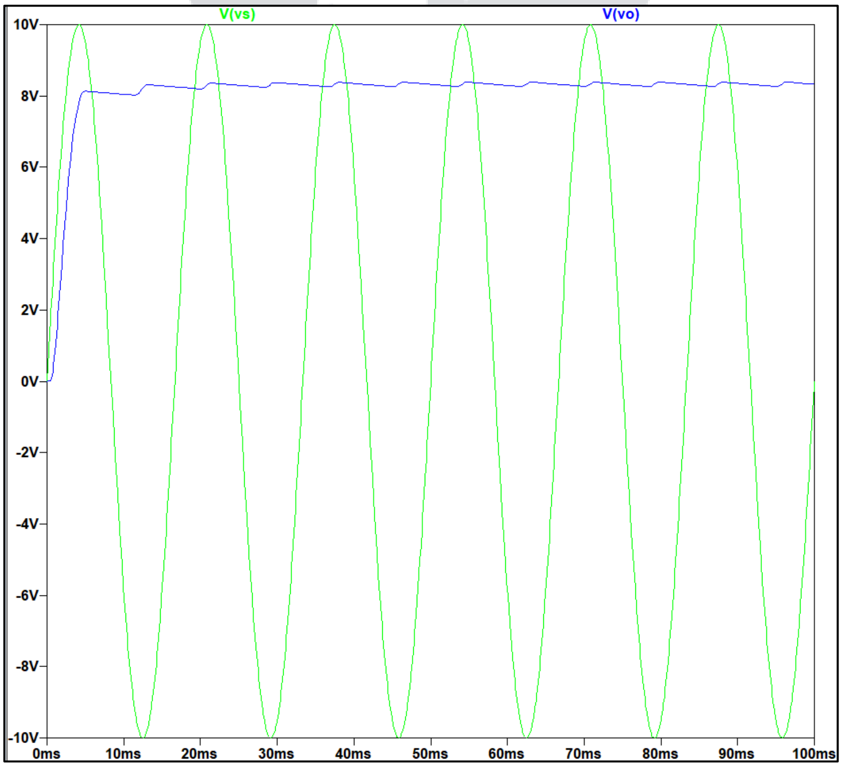

Fig 14. Full Wave Bridge Rectifier with Filter

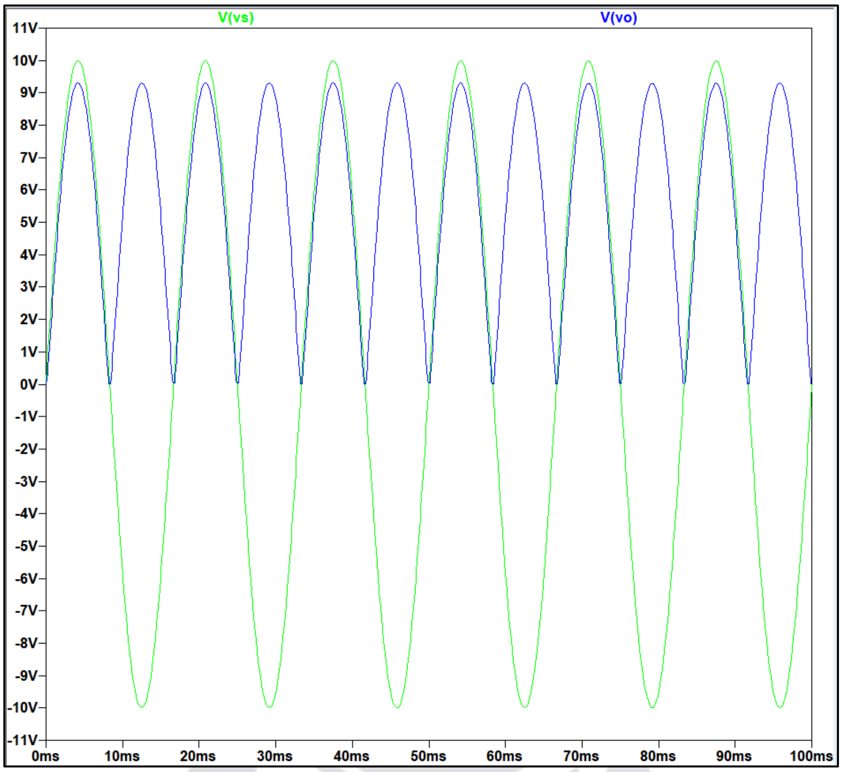

Fig 15. Full Wave Centre Tapped Rectifier without Filter

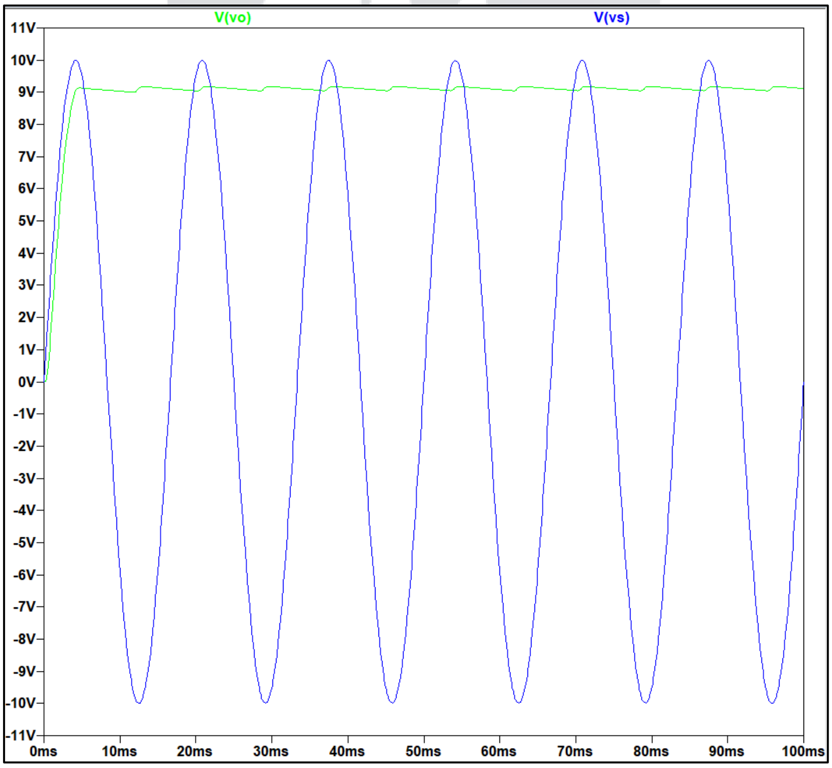

Fig 16. Full Wave Centre Tapped Rectifier with Filter

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} –

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

$$\boxed{\gamma = 0.48}$$

➢ With Filter ↪

$$Ripple\ Factor = \gamma = \frac{1}{4\sqrt{3}fR_LC}$$

$$\gamma = \frac{1}{4\sqrt{3} \times 60 \times 10^3 \times 470 \times 10^{-6}}$$

$$\boxed{\gamma = 0.005}$$

Efficiency remains the same in both cases -

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

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

$$\boxed{\eta = 81.2\%}$$

Result ↬

For a full-wave rectifier without a filter, the ripple factor (RF) is approximately 0.48, and the maximum theoretical efficiency is about 81.2%. When a capacitor filter is added, the ripple factor significantly reduces to around 0.005 or less, while the efficiency remains close to 81.2%, 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 full-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.