Aneesh Panchal - 2K20/MC/21

Experiment II

AIM:

Design a Half Wave Rectifier:

1. Without Capacitive Filter
2. With Capacitive Filter

Theory:

Rectifier:

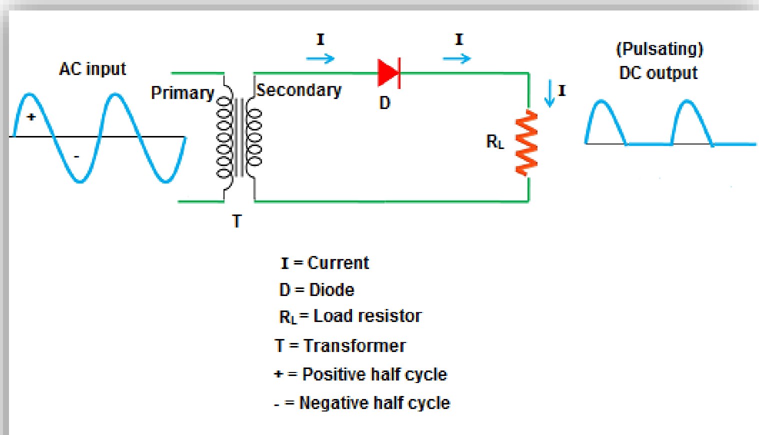
Junction diode allows current to pass only when it is forward biased. So, if an alternating voltage is applied across a diode, the current flows only in that part of the cycle, when the diode is forward biased. This property is used to rectify alternating voltages and the circuit used for this purpose is called a rectifier.

Half wave Rectifier:

In half-wave rectifier of the single phase supply, either the positive or negative half of the AC wave is passed, while the other half is blocked.

Because only one-half of the input waveform reaches the output, mean voltage is lower. Half-wave rectifier requires a single diode in a single phase supply.

Half-wave produce for more ripple than full-wave rectifiers, and much more filtering is needed to eliminate harmonics of the AC frequency from the output.



Half wave rectifier

Working:

1. A high AC voltage is applied to the to the primary side of the step-down transformer and we will get a low voltage at the secondary winding which will be applied to the diode.
2. During the positive half cycle of the AC voltage, the diode will be forward biased and the current flows through the diode.
3. During the negative half cycle of the AC voltage, the diode will be reverse biased and the flow of current will be blocked.
4. The final output voltage waveform on the secondary side is only the upper half of the Input AC voltage.

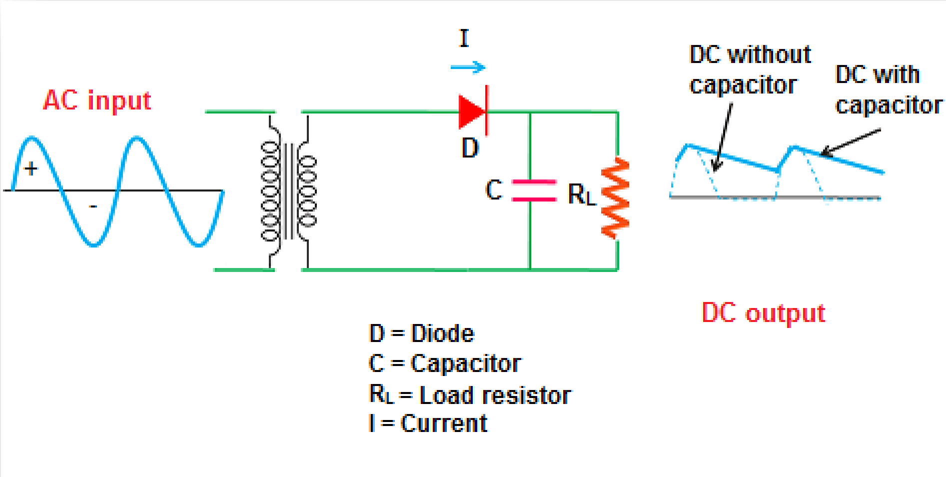
Half Wave Rectifier Capacitor Filter

Filters are components used to convert (smoothen) pulsating DC waveforms into constant DC waveforms. They achieve this by suppressing the DC ripples in the waveform.

A capacitor is widely used as filter for the Half wave Rectifier.

A capacitor does this by absorbing the excess of voltage and supplying it whenever it is required. This accounts for several charging and discharging cycles occurring in the capacitor.

Thus, this leads to clearing off the ripples by making the output waveform quite smooth.



Half wave rectifier with capacitor filter

Circuit Analysis:

Let input AC voltage be V_{in} with frequency v, Phase 0 degrees and RMS voltage V_{rms}

$$V_{initial} = V_{pk}\sin(2\pi vt + 0)\,V = V_{pk}\sin(2\pi vt)\,V$$

Input AC voltage for Diode after passing through the Transformer,

$$V_{in} = \frac{n_s}{n_p} V_{initial}\sqrt{2}\sin(2\pi vt)\,V$$

Output DC Voltage (without Capacitive filter),

$$\begin{aligned} V_{out} &= V_{in} \quad ,when\ \sin(2\pi vt) > 0 \\ &= 0 \quad ,when\ \sin(2\pi vt) \leq 0 \end{aligned}$$

Ripple Factor:

Ripple is the residual periodic variation of the DC voltage within a power supply which has been derived from an alternating current (AC) source.

$$r_{without\ filter} = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = 1.21\ (approx)$$

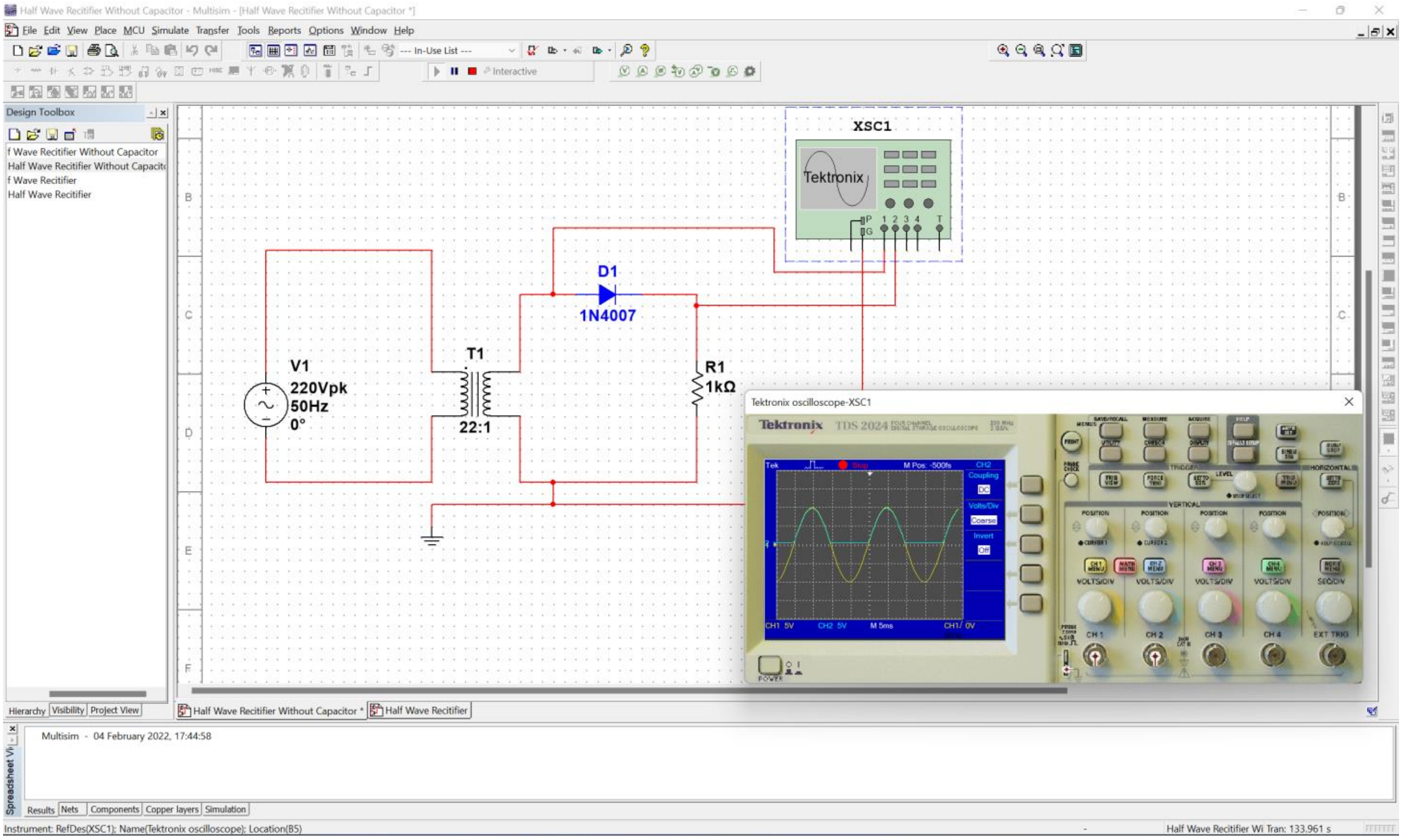
$$r_{with\ filter} = \frac{1}{2\sqrt{3}vRC}$$

Observations:

Half Wave Rectifier (without Capacitive filter):

Without Capacitive filter we only get Positive portion of the input AC wave as the output DC wave because of the forward junction diode.

When the input voltage is negative then output voltage gets the value as zero.



Here we get the Blue wave as the output wave from the Yellow input wave.

Here the equations are as follows,

Input AC Voltage (Yellow Wave),

$$V_{initial} = 220\sin(100\pi t)\,V$$

$$V_{in} = \frac{1}{22}220\sin(100\pi t)\,V = 10\sin(100\pi t)\,V$$

Output DC Voltage (Blue Wave),

$$V_{out} = 10\sin(100\pi t)\ \ , when\ \sin(100\pi t) > 0$$

$$= 0\ \ , when\ \sin(100\pi t) \leq 0$$

Ripple Factor,

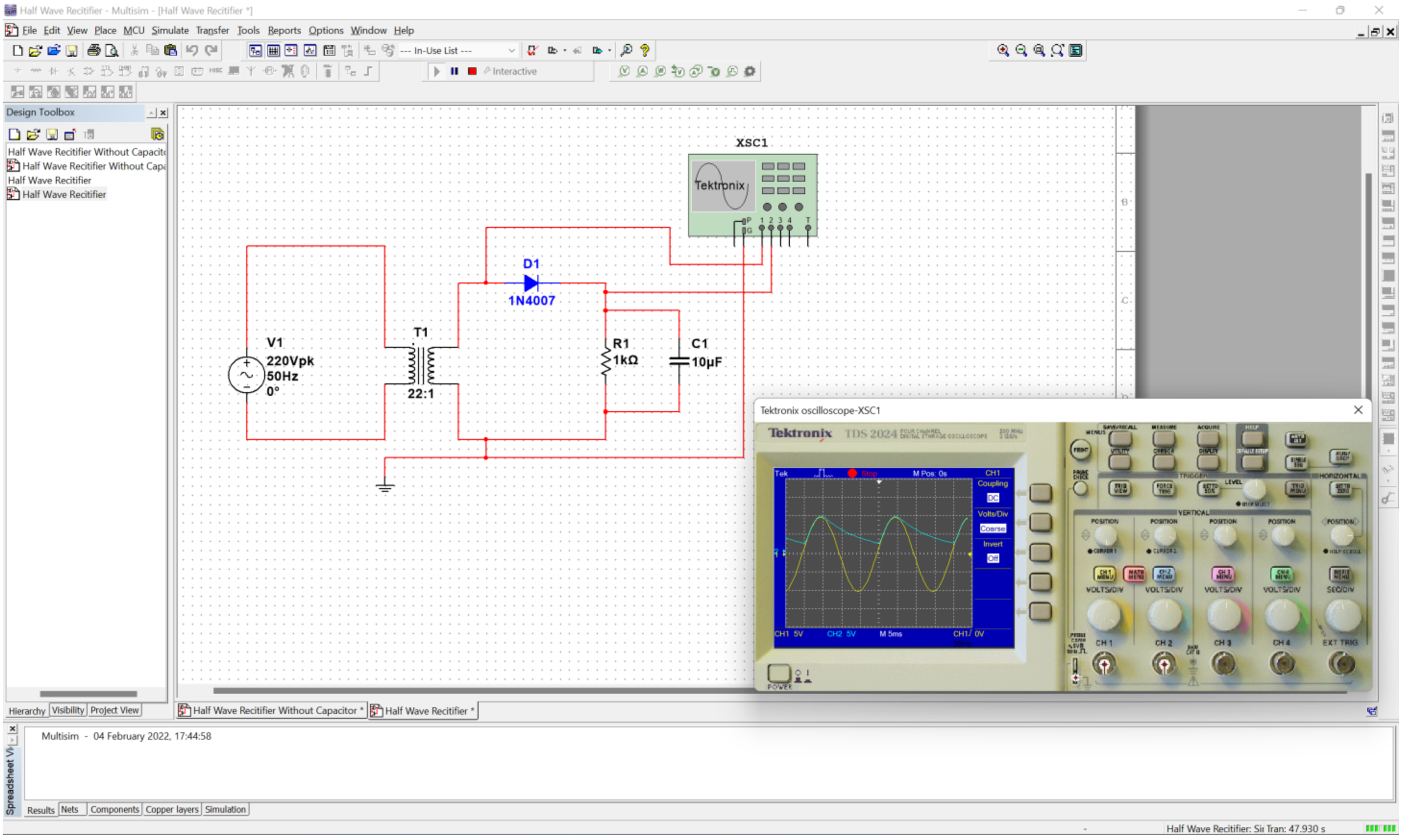
$$r_{without\ filter} = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = 1.21\ (approx)$$

Half Wave Rectifier (with Capacitive filter):

With capacitive filter we can get some ripples and we can manage ripples value using value of Capacitor i.e. either we increase or decrease them.

Capacitor do it using charging and discharging.

Case I (Capacitor = 10 micro farad):



Here we get ripples as Blue wave from the Yellow input wave.

Here the equations are as follows,

Input AC Voltage (Yellow Wave),

$$V_{initial} = 220\sin(100\pi t)\,V$$

$$V_{in} = \frac{1}{22}220\sin(100\pi t)\,V = 10\sin(100\pi t)\,V$$

$$R = 1000\ ohm$$

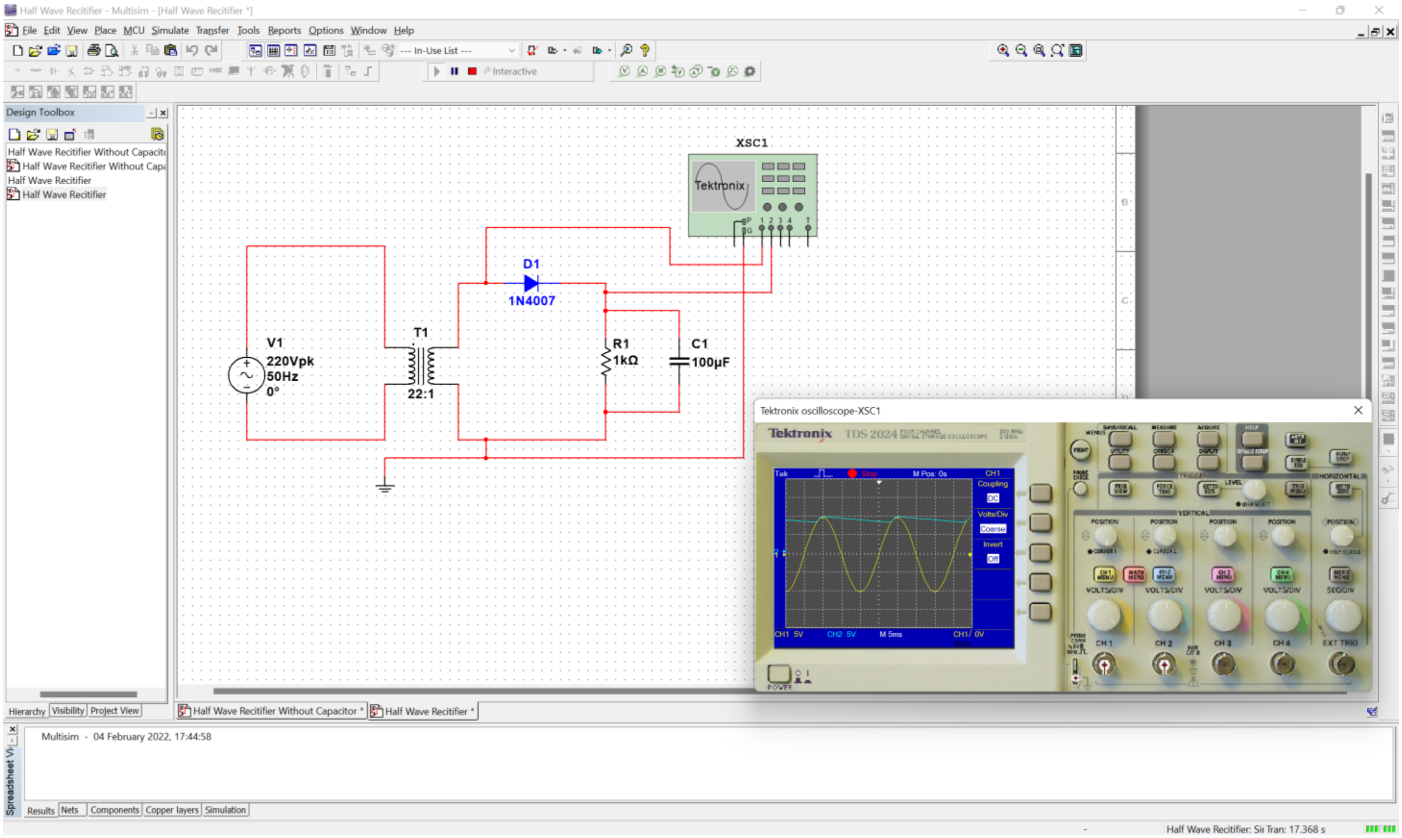
$$C = 10\ X\ 10^{-6}\ f$$

$$v = 50\ Hz$$

Ripple Factor,

$$r_{with\ filter} = \frac{1}{2\sqrt{3}vRC} = \frac{10^6}{2\sqrt{3}\ X\ 50\ X\ 10^3\ X\ 10} = 0.577$$

Case II (Capacitor = 100 micro farad):



Here we get ripples as Blue wave (less bumps than previous case) from Yellow input wave. Here the equations are as follows,

Input AC Voltage (Yellow Wave),

$$V_{initial} = 220\sin(100\pi t)\,V$$

$$V_{in} = \frac{1}{22}220\sin(100\pi t)\,V = 10\sin(100\pi t)\,V$$

$$R = 1000\ ohm$$

$$C = 100\ X\ 10^{-6}\ f$$

$$v = 50\ Hz$$

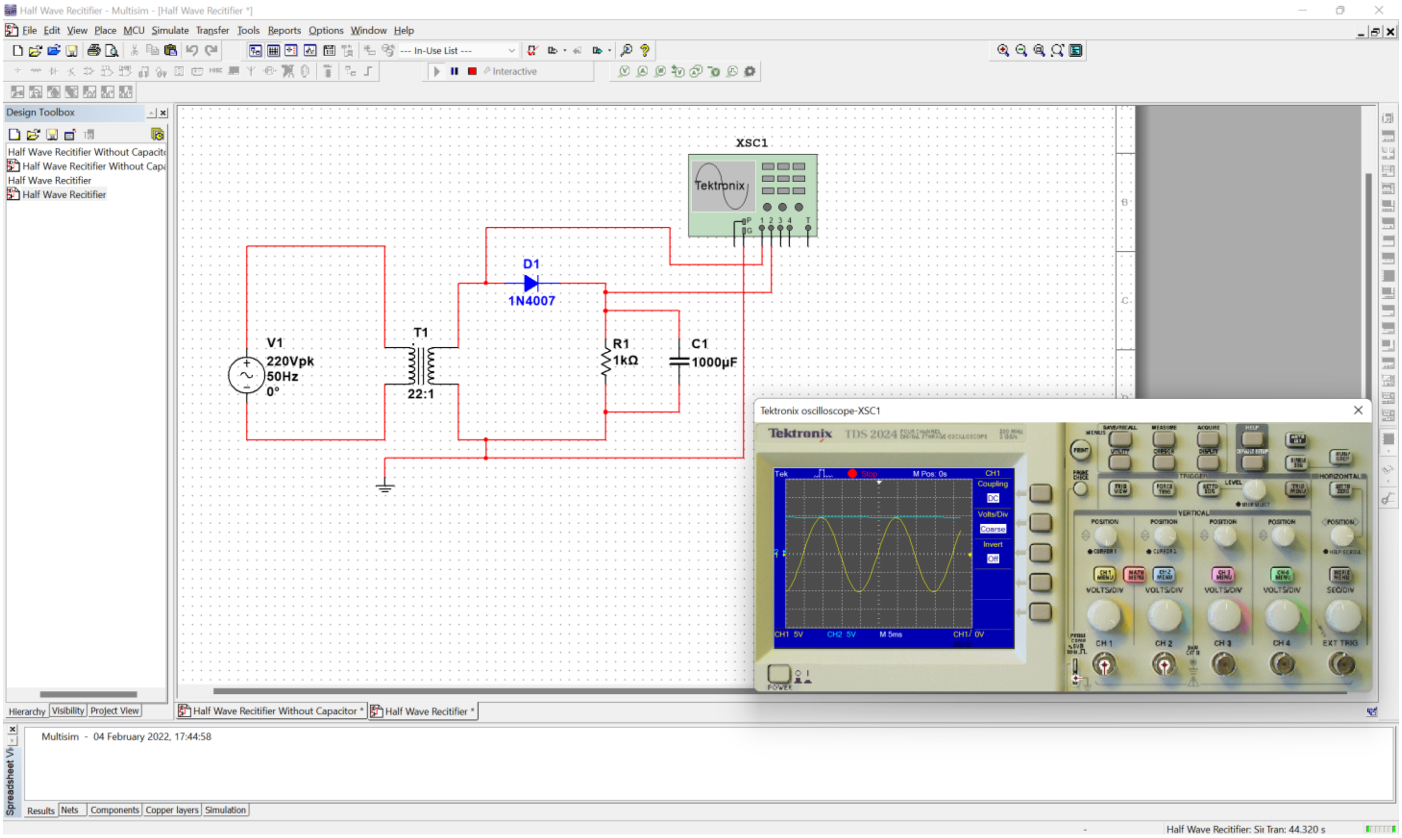
Ripple Factor,

$$r_{with\ filter} = \frac{1}{2\sqrt{3}vRC} = \frac{10^6}{2\sqrt{3}\ X\ 50\ X\ 10^3\ X\ 100} = 0.0577$$

As here Ripple factor is less than the case I,

It means and shows that here we get less bumps in the output wave that is less ripples as compared to the previous case.

Case III (Capacitor = 1k micro farad):



Here we get ripples as Blue wave (negligible) from the Yellow input wave.
Here the equations are as follows,

Input AC Voltage (Yellow Wave),

$V_{initial} = 220 \sin(100\pi t)\, V$

$V_{in} = \frac{1}{22} 220 \sin(100\pi t)\, V = 10 \sin(100\pi t)\, V$

$R = 1000\ ohm$

$C = 1k\ X\ 10^{-6}\ f$

$v = 50\ Hz$

Ripple Factor,

$r_{with\ filter} = \frac{1}{2\sqrt{3}vRC} = \frac{10^6}{2\sqrt{3}\ X\ 50\ X\ 10^3\ X\ 10^3} = 0.00577$

Here we can see that output wave is nearly a straight line.
As here Ripple factor is less than the case I and case II,
It means and shows that here we get less bumps in the output wave that is less ripples as compared to the previous cases.
Conclusion is this as we increase the value of Capacitive filter, it will decrease the ripples and flattens the output wave.