Experiment - 3

Aim:- To study working and various parameters of rectification using half wave and full-wave rectifier and regulation using capacitor filter, Zener diode and IC 7806.

Apparatus Required:-

1. Plastic circuit board
2. 220 AC Source / Signal generator.
3. Cathode Ray Oscilloscope
4. Connecting Wire
5. Probes

Description:- Rectifier is a device that can convert alternating current (AC) to direct current, i.e, the process of one-way flow of current and this process is called rectification.

Rectifier can be of shapes of several different physical forms such as solid state diodes, vaccum-tube diodes, mercury-arc values, silicon controlled rectifiers

Half wave rectifier:- It rectifies only half cycle of waveform. It consist a step down transformer, a diode connected to the transformer and a load resistance connected to cathode end of diode.

Main supply voltage is reduced by

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step down transformer. Decreased AC voltage is given to the diode which is connected serial to the secondary winding of transformer.

Diode is an electric component which allows only forward biased current and not reverse biased current. From the diode, we will get pulsating DC at the load resistance.

$$\text{efficiency}, \eta = \frac{P_{dc}}{P_{ac}}$$

$$\text{ripple factor}, \gamma = \frac{V_{r(rms)}}{V_{dc}}$$

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Full wave rectifier :- It converts an AC voltage into a pulsating DC voltage using both half cycles of the applied AC voltage. It use two diodes of which one conducts during one half cycle while the other conducts during the other half cycle of the applied ac voltage.

For single phase AC, if the transformer is centre taped, then two diodes back to back forms full-wave rectifier. It converts the input waveform to one of constant polarity by reversing the negative portions of the alternating current waveform leading to double the frequency of the output waveform.

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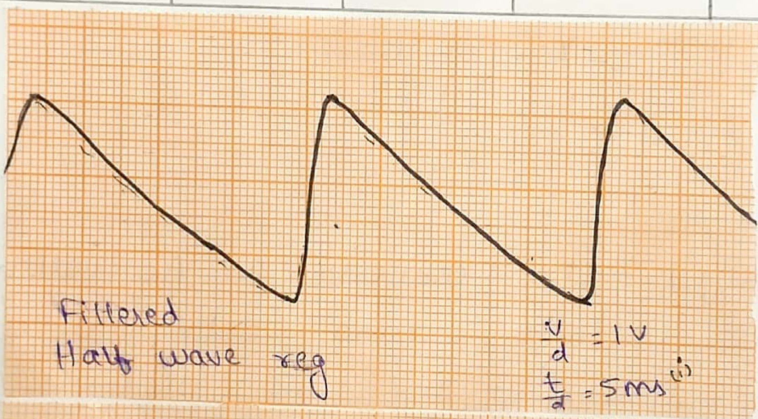
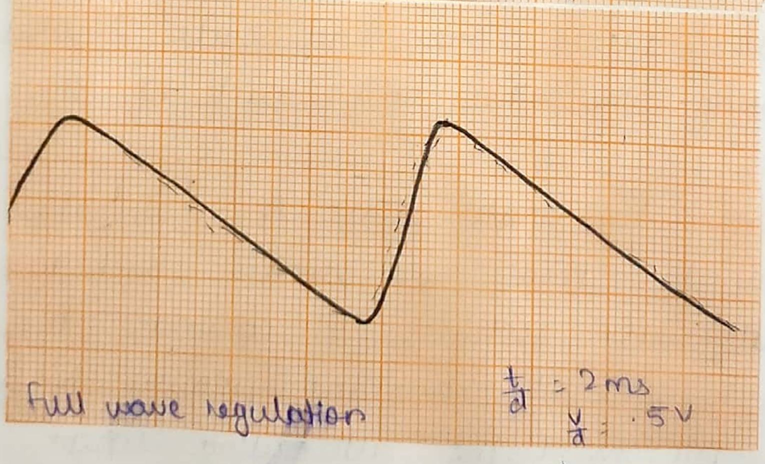
Voltage Regulation

Rectifier	V_{nL}	V_{RL_1}	V_{RL_2}	$V^{R}_{L_1 \parallel L_2}$	$V_R = \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right) \times 100$
Half wave	4.58	4.49	4.53	4.50	0.0178 → 1.78%
Full wave	9.16	8.99	9.09	8.95	0.234 → 2.34%
Full wave bridge	8.54	8.34	8.42	8.24	0.364 → 3.64%
with Zenor	4.61	4.56	4.59	4.54	0.0154 → 1.54%
with IC7806	4.97	4.53	4.92	4.36	0.1399 → 14%



$V_{r(p-p)} = 2.8V$



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ripple factor, $\gamma = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1}$

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

Bridge-wave rectifier:- It uses four individual rectifying diodes connected in a closed loop "bridge" configuration to produce desired output. It does not require a centre tapped transformer, thereby reducing its size and cost

Voltage regulation:- Measure of how well a power transformer maintains constant secondary voltage over a range of load currents is called transformer's voltage regulation.

$$\text{Regulation percentage} = \frac{V_{no\text{-}load} - V_{full\ load}}{V_{full\text{-}load}} \times 100\%$$

Calculations:- Half wave rectifier:-

$V_m = \cancel{16V}$ ($\cancel{2.8 \times 5}$) 13.5 V $V_r(rms) = 0.385 V_m = 5.1975$ V

	observed	Multimeter	Calculated
V_{dc}	4 V	4.6 V	$\frac{V_m}{\pi} = 4.29$ V

$$\text{Ripple factor} = r = \frac{V_r(rms)}{V_{DC}} = \frac{5.1975}{4.29} = 1.211$$

$\%\, r = 121.1\,\%$

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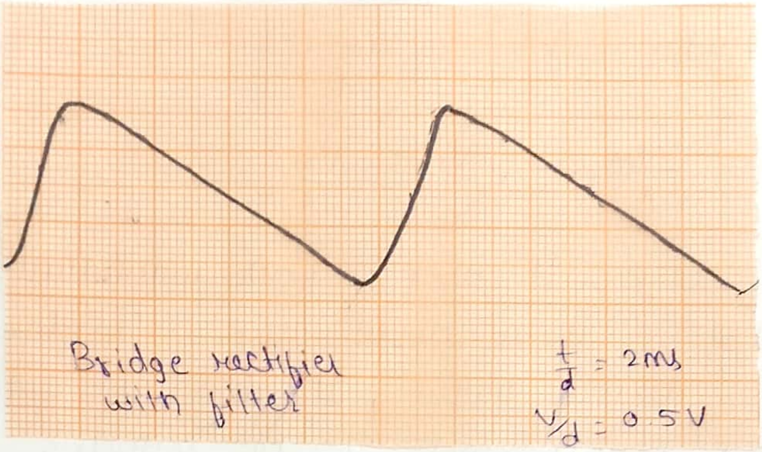
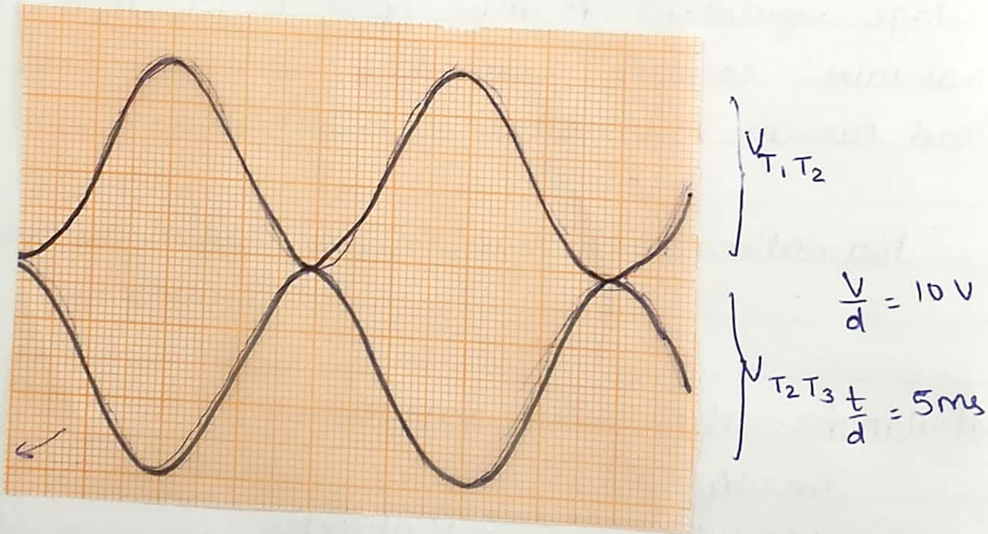


Bridge rectifier
with filter
t/d = 2ms
V/d = 0.5V



V T1, T2
V/d = 10V
V T2 T3
t/d = 5ms

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Half wave Rectifier with capacitor filter :-

$V_r(p-p) = \cancel{4}2.8$ V $\qquad V_{rms} = \frac{V_r(p-p)}{2\sqrt{3}} = 0.808$ V

$V_{dc} = \cancel{8V}$ 11.6 , $\cancel{9.7V}$ 12.8 (multimeter)

Full-wave rectifier :-

$V_m = \cancel{16.5V}$ 14 V

$V_r(rms) = 0.308\, V_m = 4.312$ V

	Observed	Multimeter	Calculated
Vdc	~~11.~~ 68	~~12.8~~ 9.1	$\frac{2V_m}{\pi} = 8.9126$ V

Ripple factor, $r = \frac{V_r(rms)}{V_{dc}} = 0.484$

$\% r = 48.4\%$

Full wave rectifier with capacitor filter

$V_r(p-p) = 1.4$ V $\qquad V_r(rms) = \frac{V_r(p-p)}{2\sqrt{3}} = 0.404$ V

$V_{dc} = 12.8$ V , 13.7 V (multimeter)

Full wave Bridge Rectifier

$V_m = 13$ V $\qquad V_r(rms) = 0.308\, V_m = 4.004$ V

	Observed	Multimeter	Calculated
Vdc →	8 V	8.5 V	8.276 V

Ripple factor, $r = \frac{V_r(rms)}{V_{dc}} = 0.4838$

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$\% r = 48.38\%$

Full wave Bridge Rectifier with capacitor filter.

$V_r(p-p) = 1.3\,V$ $V_r(rms) = \frac{V_r(p-p)}{2\sqrt{3}} = 0.375\,V$

$V_{dc} = 12\,V$, 12.97 (multimeter)

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Discussions :-

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1. Half wave and full wave filters made using diodes supply less voltage than input as there will be voltage drop across the diodes which will be around cut in voltage may lead to deviations from ideal state

2. During reversed bias state, voltage has to be maintained below zener breakdown voltage.

3. Vdc ~~at~~ in case of full wave rectifier was observed to be around double the case of half wave rectifier because both cycles may contribute to output whereas only half cycle is contributing to output in half wave rectifier.

4. Observed and calculated values of Vdc were in experimental range of error

5. Time constant of the capacitor filter should be quite enough so that capacitor doesn't discharge within short range of time.

6. Bridge rectifier loss of input voltage is around double than the case of loss in full wave rectifier but it requires half of secondary windings and less cost as compared to full wave rectifier.

7. Slightly inclined baselines were observed in AC coupled output because of presence of capacitor in oscilloscope to pass AC components in series with circuit.

8. Maximum load applied was maximum of L_1 or L_2 as ~~the~~ it was not possible to add loads in series to each other.

9. ~~A~~ Zener diode and IC-7806 did not differ much in their output but the difference is zener diode voltage drop varies significantly with current, temperature whereas IC has four stages to work on a voltage reference, an error amplifier, series pass transistor and feedback circuit. When output voltage drops or increase, the feedback circuit senses the change and send that change to error amplifier who inverses the voltage and drives the series pass element in opposite direction.

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DISCUSSIONS:

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Rectifiers:

- Half wave and full wave rectifiers can be formed using diodes. In half wave rectifier, we are able to tap only positive cycle of input voltage while we tap both polarities and convert them to single polarity in full wave rectifier.

The maximum of output voltage shall be approximately Maximum in input voltage - diode cut-in voltage owing to voltage drop across the diode in case of centre-tapped rectifier or half wave rectifier. In case of bridge rectifier, there are two diodes for each circuit in forward bias, thus,

$$v_{O,max} = v_{I,max} - 2V_r.$$

- The dc equivalent of half-wave rectifier is:

$$V_{dc} = \frac{1}{2\pi}\int_0^{2\pi} V_m \sin\theta \, d\theta = V_m/\pi.$$

while in case of full-wave rectifier, it is $2V_m/\pi = 2V_{dc}$.

Similarly ac part of half-wave rectifier $= \sqrt{\left[\frac{1}{2\pi}\int_0^{2\pi} V_m^2 \sin^2\theta \, d\theta\right]}$

$= V_m/2.$

while for full-wave it is $V_m/\sqrt{2}$.

considering efficiency: $\eta = \frac{P_{dc}}{P_{ac}} = \frac{V_{dc}^2}{V_{ac}^2} = 0.406$ (half-wave)

$= 0.812$ (full-wave)

Thus, $\eta_{full\text{-}wave} = 2 \cdot \eta_{half\text{-}wave}$.

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- Next, we shall compare bridge rectifier and centre-tapped rectifier: for bridge; we have $V_{o,max} = V_{i\,max} - 2V_\gamma$
while for centre-tapped, $V_{o\,max} = V_{i\,max} - V_\gamma$
However for centre-tapped rectifier, PIV of diodes required is aproximately $2V_s$, while it is V_s for bridge-rectifier. Also very accurate turns ratio is required for centre-tapping. Thus, bridge rectifiers are more practical.

- Filters:
A capacitor attached parallel to load voltage acts as rectifier. ~~We~~ In an ideal case, the time constant of the resulting RC circuit should be zero such that ripple voltage $(V_r) \to 0$. However for practical cases in full-bridge rectifiers, we assume $V_r = \dfrac{V_m}{2fRC}$, where $R \to$ load
$V_m \to V_{output}$ maximum
$f \to$ source frequency.
These results have been observed and concluded from this experiments, within experimental ranges of error.
We also observe slightly inclined baselines in CRO, due to presence of capacitor required to pass AC components in series with circuit.

- Voltage Regulation:
In this experiment, we have used zener diode regulation and IC 7806 regulations using Bridge rectifier. In our experiment, the two results did not differ significantly. ~~Als~~
Also for proper ~~reg~~ regulation, V. applied across zener should be above V_z all the time (to eradicate V_r or $V_r \to 0$).

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we calculated regulation using $V.R = \frac{V_{NL} - V_{FL}}{V_{FL}}$.

Here the full load case is maximum of load 1 or load 2 since there wasn't any provision to connect them in series.

Lastly, we realise that IC 7806 Regulation is better than zener diode regulation since zener diode regulation is susceptible to temperature changes and current changes across diode (presence of resistance in practical cases), while IC7806 has a feedback circuit that helps to maintain constant output voltage.

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