Working of Full wave center tapped rectifier with waveforms

Reference: Integrated Electronics by Millman Halkias and Electronic devices by Floyd

F. Full-Wave Rectification :-

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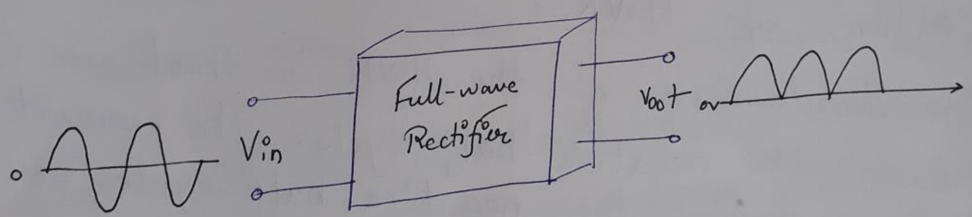
- A full-wave rectifier allows uni-directional (one-way) current through the load during the entire 360° of the input cycle.
- The result of full-wave rectification is an output voltage with a frequency twice the ippot frequency and that pulsates every half-cycle of the input, as show in fig (1.a)



- Two circuits commonly used for full-wave rectification are:

1. Center-tap Full-Wave Rectifier.
2. Full-wave Bridge Rectifier.

Center-Tapped Full-wave Rectifier :- 19

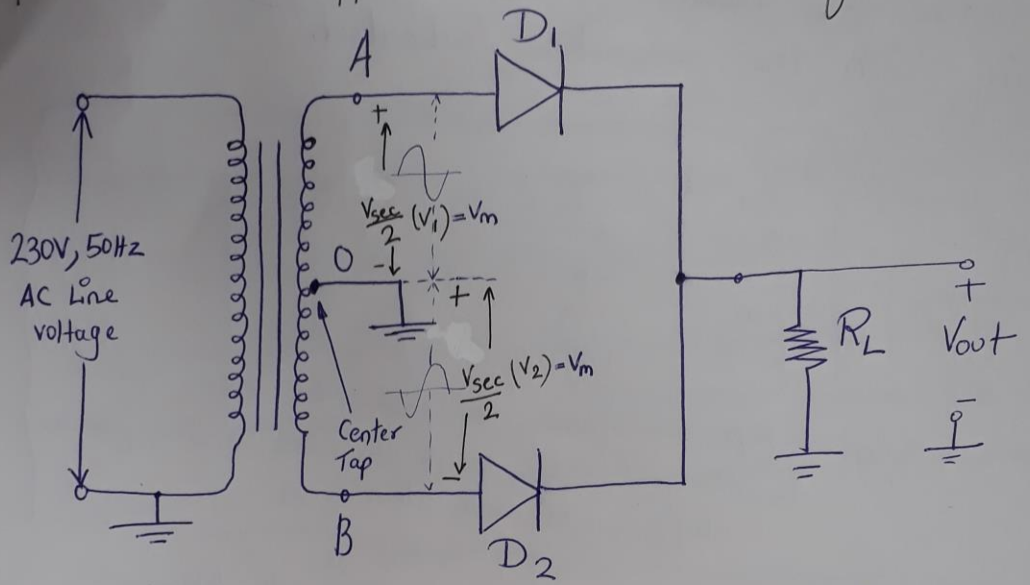


fig 1.b : Center-tapped Full-wave rectifier

Description:-

- This circuit in fig(1.b) uses two diodes D_1 & D_2 connected to the secondary of a center-tapped transformer.
- The input to the rectifier consists of a center-tapped transformer, in which the input is normally a 230V, 50Hz ac line voltage.
- Here, the transformer secondary winding is center-tapped to provide two equal voltages $\frac{V_{sec}}{2}$

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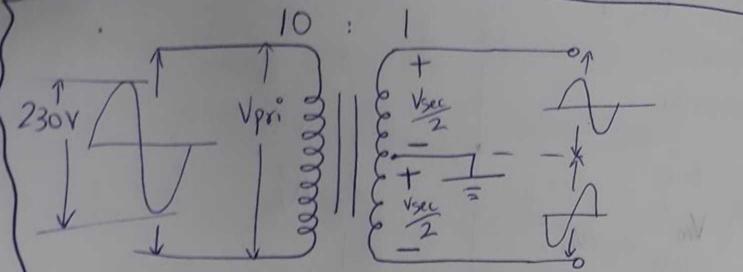
• across the two halves of the secondary winding with the polarities indicated.



Center-tap transformer → provides two equal voltages $\left(\frac{V_{sec}}{2}\right)$ which are 180° out of phase shift with each other.

- The input voltage is coupled through the transformer to the center-tapped secondary.
- Half of the total secondary voltage appears between the center-tap and each end of the secondary winding as shown in fig (1.b).
- The transformer also provides electrical isolation between the power line circuit and the electronic circuits to be biased by the rectifier circuit. This isolation reduces the risk of electrical shock.

• Working :-

1. During the positive half cycle of AC input, point A is positive and point B is negative, thus the polarities of the secondary voltages are as shown in fig 1.c

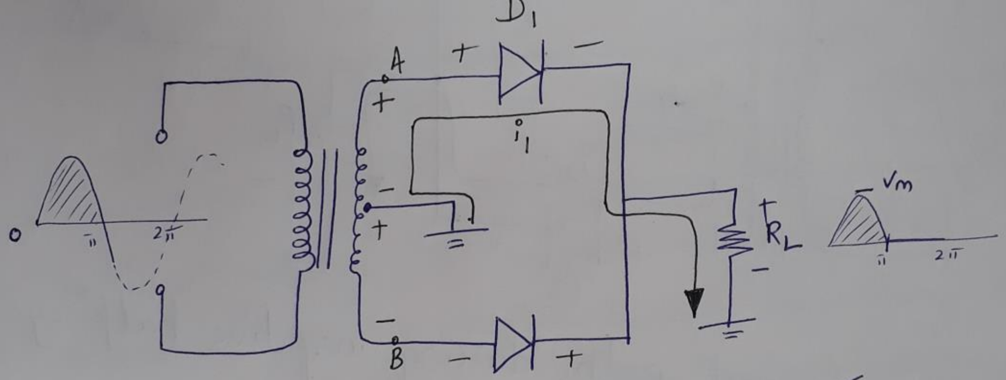


fig 1.c : Current path during positive half-cycles

- This condition forward-biases diode D_1 and reverse-biases diode D_2.
- Thus, D_1 conducts and the current i_1 flows through D_1 and the load resistor R_L, as indicated, which produces a positive O/P voltage across R_L.

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2. During the negative half-cycle of the input voltage, point A is negative and point B is positive, thus the voltage polarities on the secondary are as shown in fig (1.d).

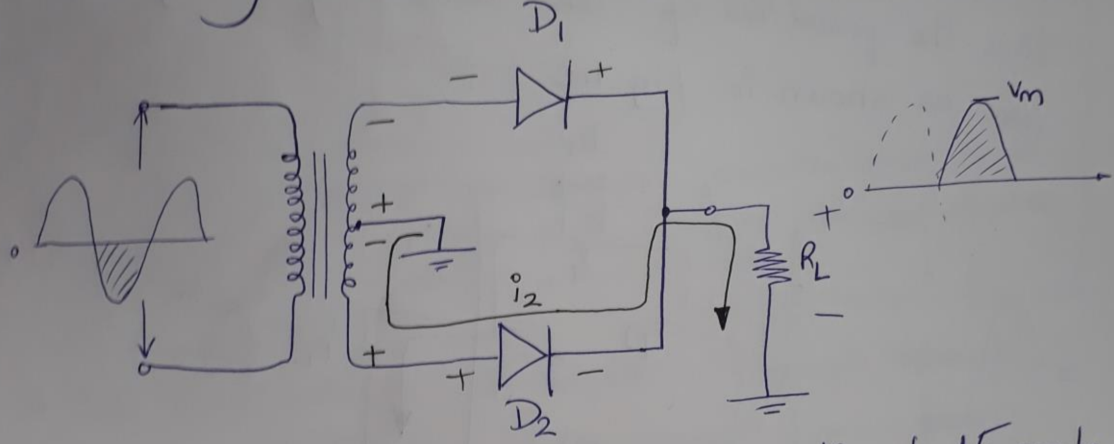

fig 1.d : Current path during negative half-cycle

- This condition reverse-biases D_1 and forward-biases D_2.
- Thus, diode D_2 conducts and the current i_2 flows through diode D_2 and load resistor R_L as indicated, which again produces a positive o/p voltage across R_L.

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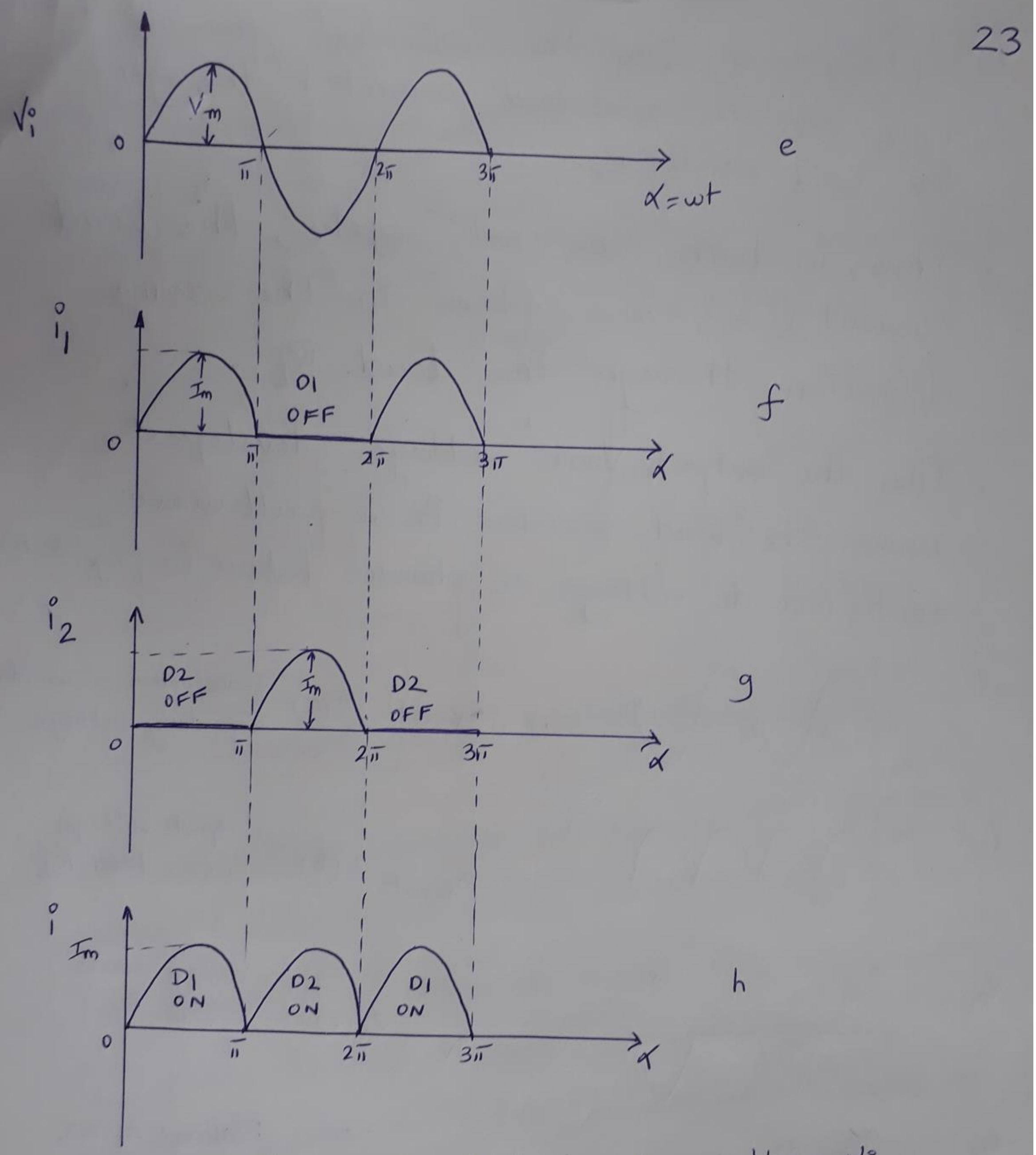


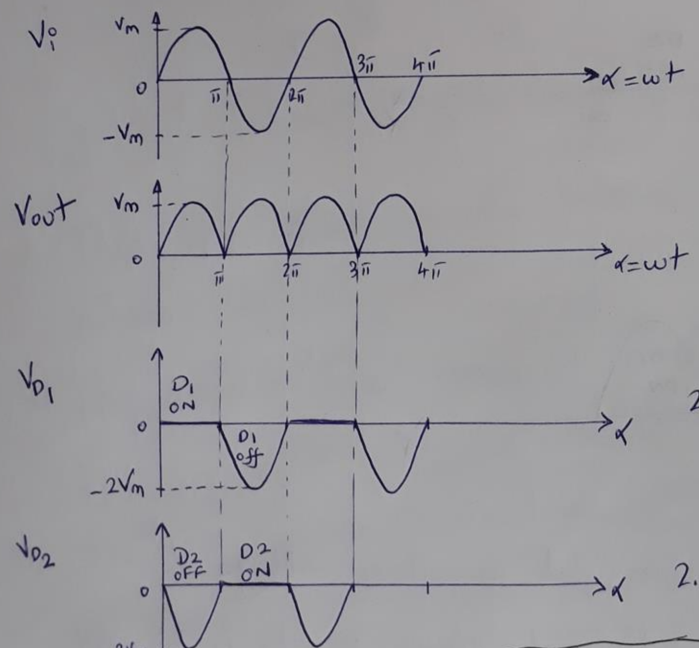
fig 1.e Transformer sinusoidal secondary voltage V_i

fig 1.f, 1.g, 1.h : The individual diode currents i_1, i_2 and the load current i. The O/P voltage is $\boxed{V_{out} = i R_L}$

- Fig 1.f, 1.g and 1.h show the individual currents i_1, i_2 and the total load current i through the load resistor R_L.

- Thus, in both the half cycles, the load current ($i = i_1 + i_2$) flows in the same direction through the load. R_L.

- Thus, the output 'Vout' voltage developed across the load resistor is a full-wave rectified dc voltage as shown below in fig (2.b)



2.(a) Transformer sinusoidal secondary voltage

2.(b) output voltage across load R_L

2. (c) Voltage across diode D_1

2. (d) Voltage across diode D_2

→ {Next: Analysis of Full-wave Center-tapped rectifier}

Reference: Microelectronics circuits by Donald Neamen and Electronic devices by Floyd

I. Full Wave Bridge Rectifier :- 37

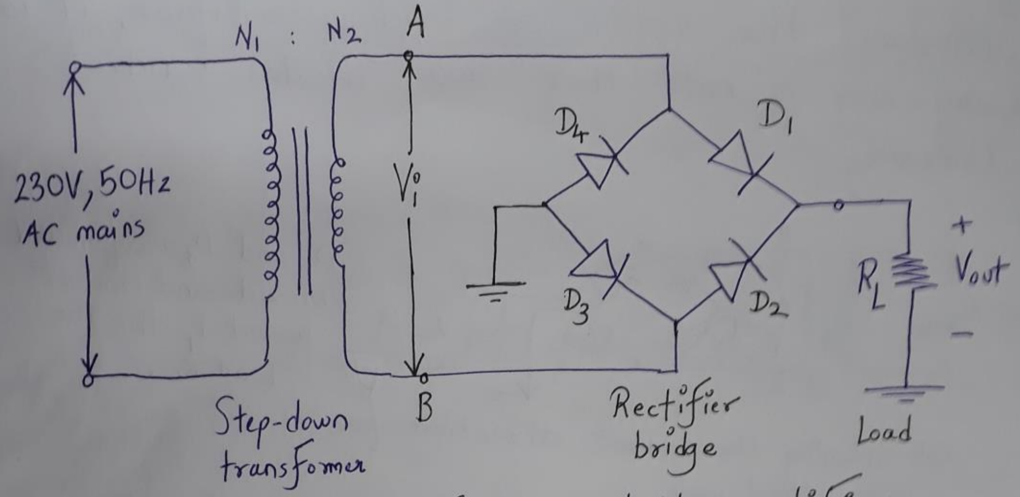


fig 4.1 : Circuit of full-wave bridge rectifier

Description:-

- It consists of a step-down transformer, four diodes and Load R_L as shown in fig 4.1
- The four diodes are connected to form a bridge circuit. Hence it is called as "Bridge Rectifier".
- A distinct advantage over full-wave center-tap rectifier is that bridge rectifier does not require a center-tapped transformer.
- The transformer provides electrical isolation between the input ac mains and the rectifier output.

Working:-

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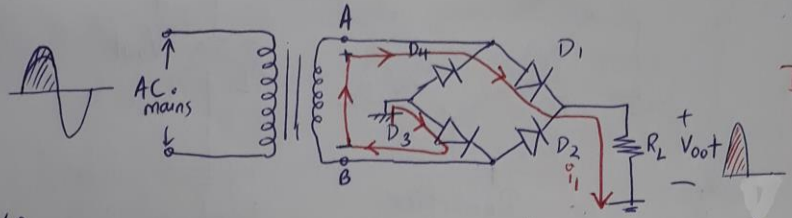
- To understand the action of bridge rectifier, it is necessary only to note that two diodes conduct simultaneously.



D_1 and D_3 are forward biased and conduct current i_1 thr the Load R_L

fig 4.2 ckt showing the current direction for a positive input cycle

1. During the positive half cycle of ac input, point A is positive and point B is negative. Therefore, diodes D_1 and D_3 are forward-biased and conduct current i_1 in the direction shown in fig 4.2.
2. The current i_1 conduction path is Point A, Diode D_1, Load R_L, diode D_3 and point B.
3. A voltage V_{out} is developed across load R_L that looks like the +ve half of the input cycle. During this cycle, diodes D_2 and D_4 are reverse-biased and do not conduct.

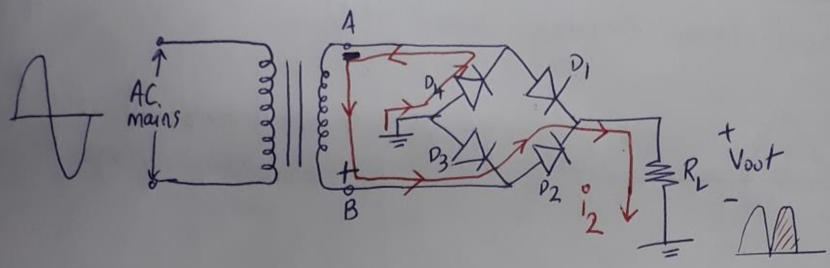
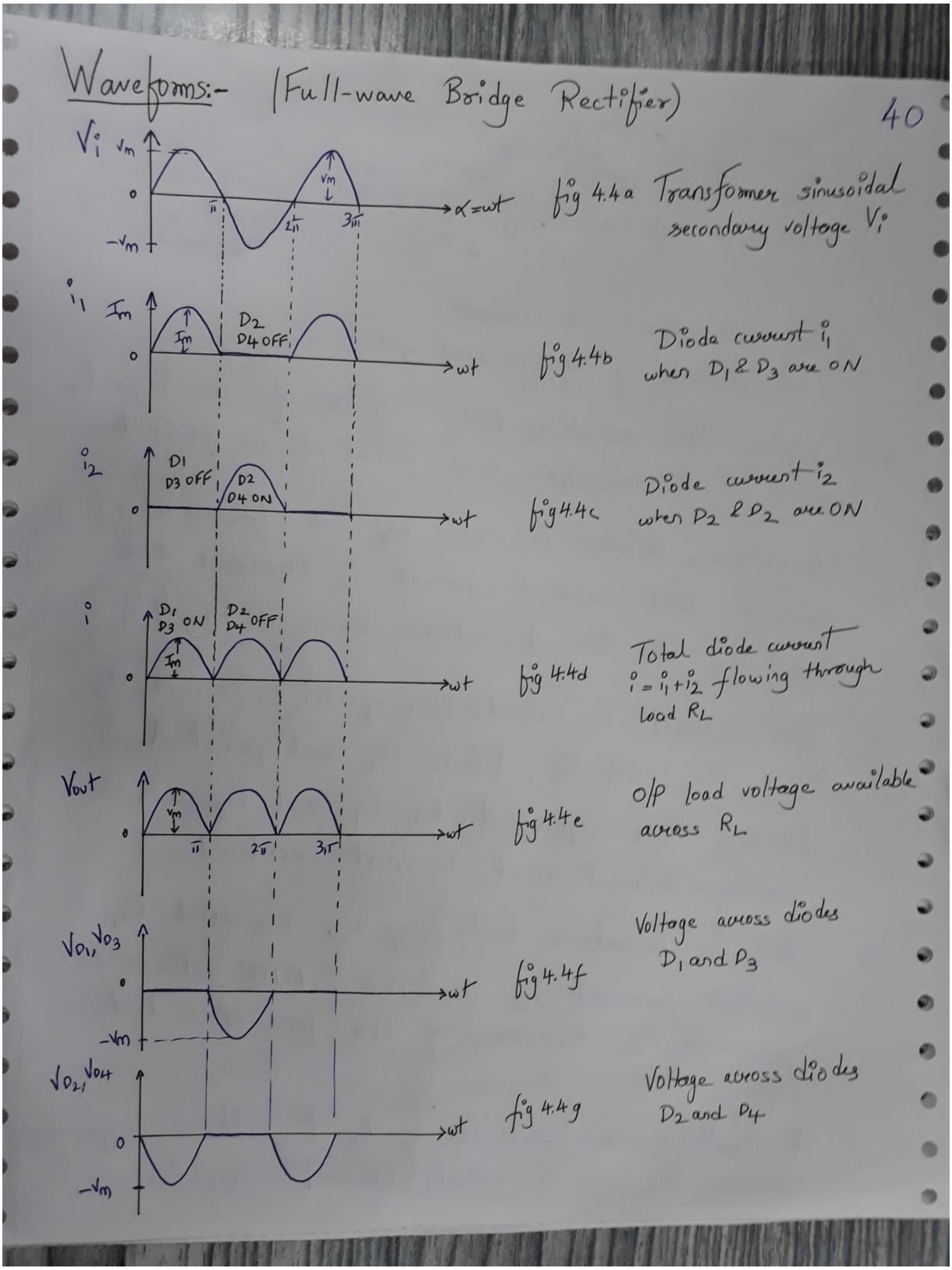


fig 4.3 ckt showing the current direction for a negative input cycle

4. During the negative half cycle of ac input, point A is negative and point B is positive. Therefore, diodes D_2 and D_4 are forward biased and conduct current i_2 through the load R_L in the direction shown in fig 4.3.
5. The current i_2 conduction path is Point B, Diode D_2, Load R_L, Diode D_4 and point A. During this cycle, diodes D_1 and D_3 are reverse-biased and do not conduct.
6. Thus, in negative half cycle, D_2 and D_4 conduct current i_2 in the SAME direction through R_L as during the positive half cycle.
7. A full-wave rectified output voltage appears across R_L as a result of this action.

Working and Analysis of Full wave bridge rectifier with waveforms and expressions



Bridge output voltage :

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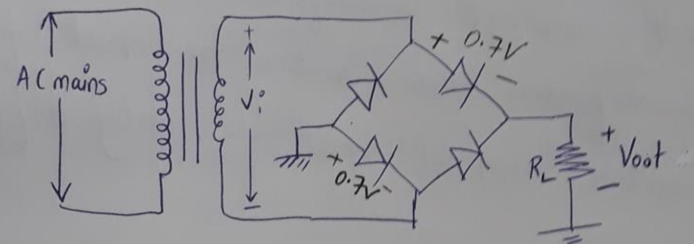

fig 4.5 Bridge operation during +ve h.c of primary and secondary voltages (Diode drops included)

- Fig shows the sinusoidal transformer secondary voltage V_i and the rectified output voltage V_{out}.
- Because two diodes are in series in the conduction path, the magnitude of V_{out} is <u>two diode drops</u> less than the magnitude of V_i.

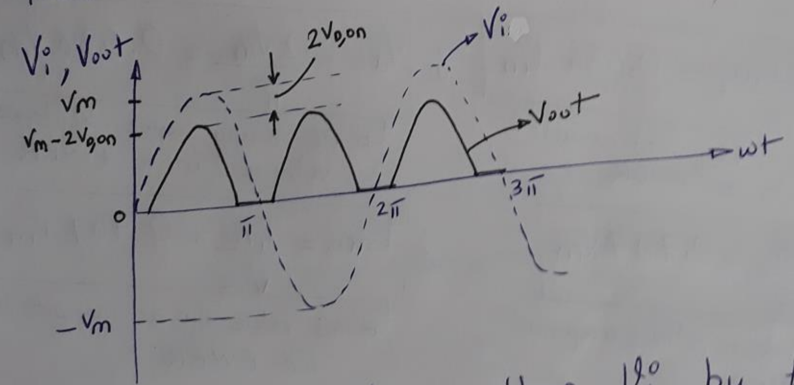

fig 4.6 Input V_i and o/p V_{out} waveforms (considering diode drops)

- Since V_{out} is lower than V_i by two diode drops (ie $2V_{D,on}$), it is somewhat a disadvantage of the bridge rectifier.

~~Analysis of Full-wave Bridge Rectifier:-~~ 42

- ~~Since the o/p current waveforms and rectified o/p voltage waveforms are similar to that of full-wave center-tapped rectifier, only difference being as follows:-~~
- ~~Considering diode drop's $V_{o,on}$ for diodes.~~

$$\boxed{V_{out_{FWCT}} = V_m - V_{o,on}} \; ; \; \boxed{V_{out_{FWBR}} = V_m - 2V_{o,on}} \rightarrow (4.1)$$

- ~~Now since magnitude of V_m is very large compared to $V_{o,on}$, we have ignored it in our analysis.~~

- The expression's for I_{dc}, V_{dc}, I_{rms} and V_{rms} will be consistent with that of Full-wave center-tap rectifier

$\therefore$ $\boxed{I_{dc} = \frac{2I_m}{\pi} = 0.636\, I_m}$; $\boxed{V_{dc} = \frac{2V_m}{\pi} = 0.636\, V_m}$

↳ DC or avg value of load current in a FWBR ; ↳ DC or avg value of load o/p voltage in a FWBR

$\therefore$ $\boxed{V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707 V_m}$; $\boxed{I_{rms} = \frac{I_m}{\sqrt{2}} = 0.707\, I_m}$

↳ rms value of ac voltage component for FWBR ; ↳ rms value of ac current component for FWBR

$\therefore$ $P_{dc} = I_{dc}^2 R_L = \left(\frac{2I_m}{\pi}\right)^2 R_L$; $P_{ac} = \frac{I_{rms}^2}{2}(R_f + R_L) = \frac{I_m^2}{2} \times (R_f + R_L)$

$$\therefore \boxed{\eta_{FWBR} = \frac{P_{dc}}{P_{ac}} \times 100 = 81.06\%} \text{ ---- Full-wave bridge rectifier} \quad (4.2)$$

From, (4.2), we can say that efficiency wise there is no difference between full-wave center-tap and full-wave bridge rectifier. 43

- Ripple in a Full-wave bridge rectifier:-

$$\gamma = \frac{I_{ac}}{I_{dc}} = \sqrt{\frac{I_{rms}^2}{I_{dc}^2} - 1}$$

$$\gamma = \sqrt{\frac{I_m^2/2}{4I_m^2/\pi^2} - 1} = \sqrt{\frac{\pi^2}{8} - 1}$$

$$\boxed{\gamma = 0.483}$$ ---- For a F.W. Bridge Rectifier

~~Observation:-~~

- ~~In the bridge rectifier, the secondary winding of the bridge ckt is not directly grounded.~~
- ~~Whereas in a center-tapped rectifier, the center tap of the secondary winding was at ground potential.~~