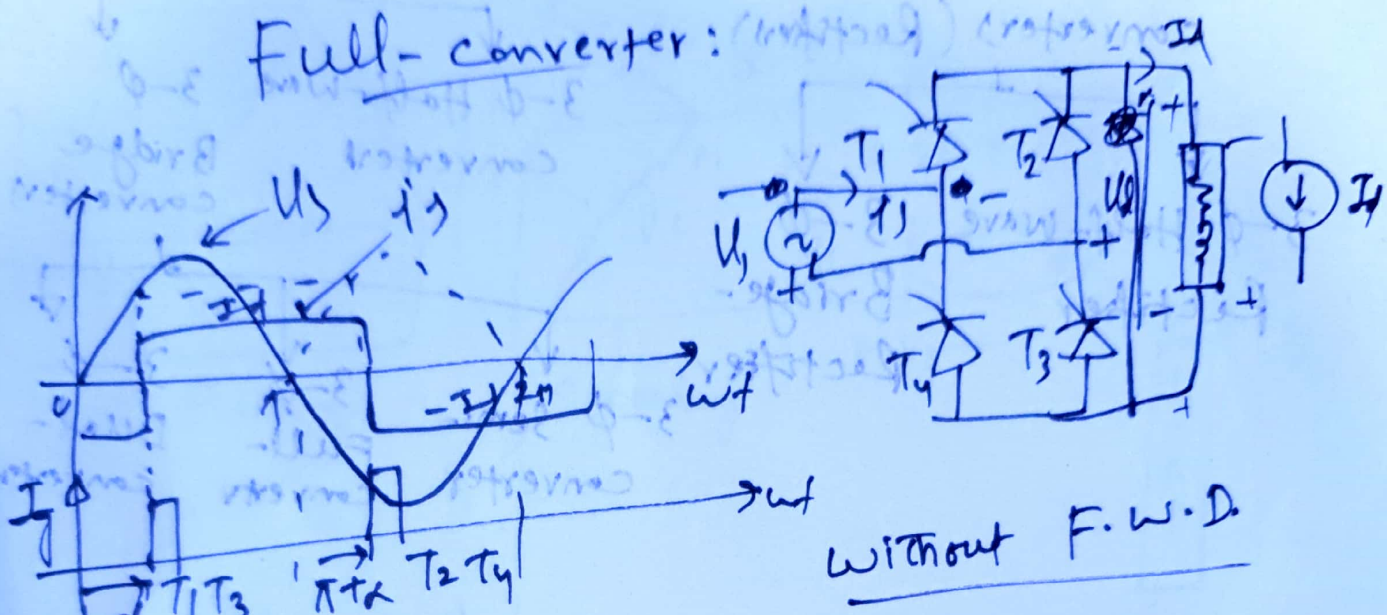
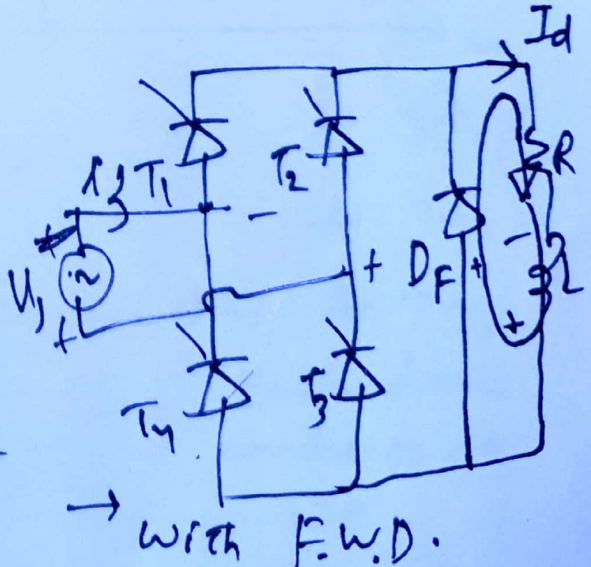
Effect of Freewheeling Diode:

For Semi-converter: Inherent freewheeling

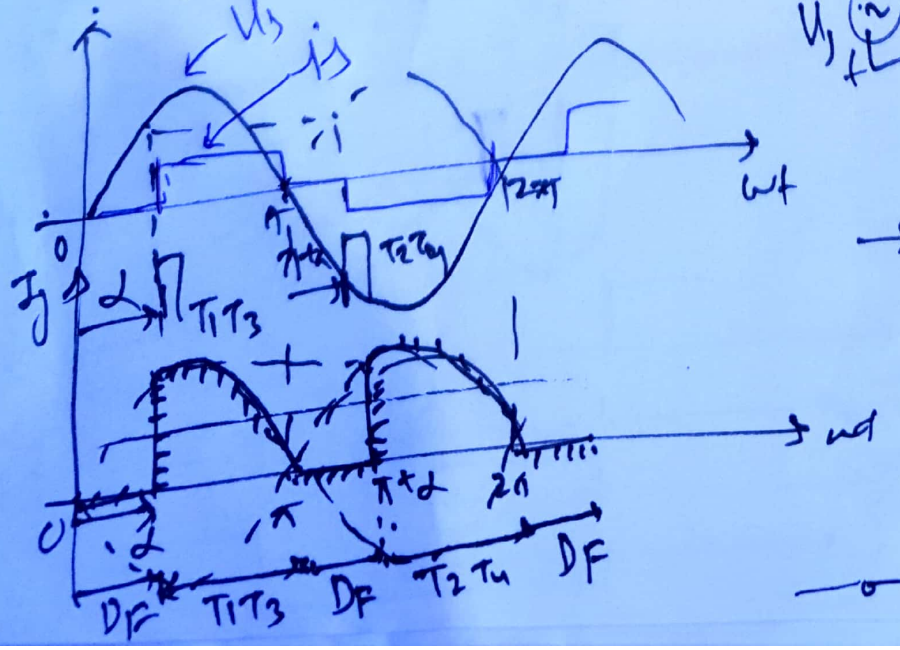
Full-converter:

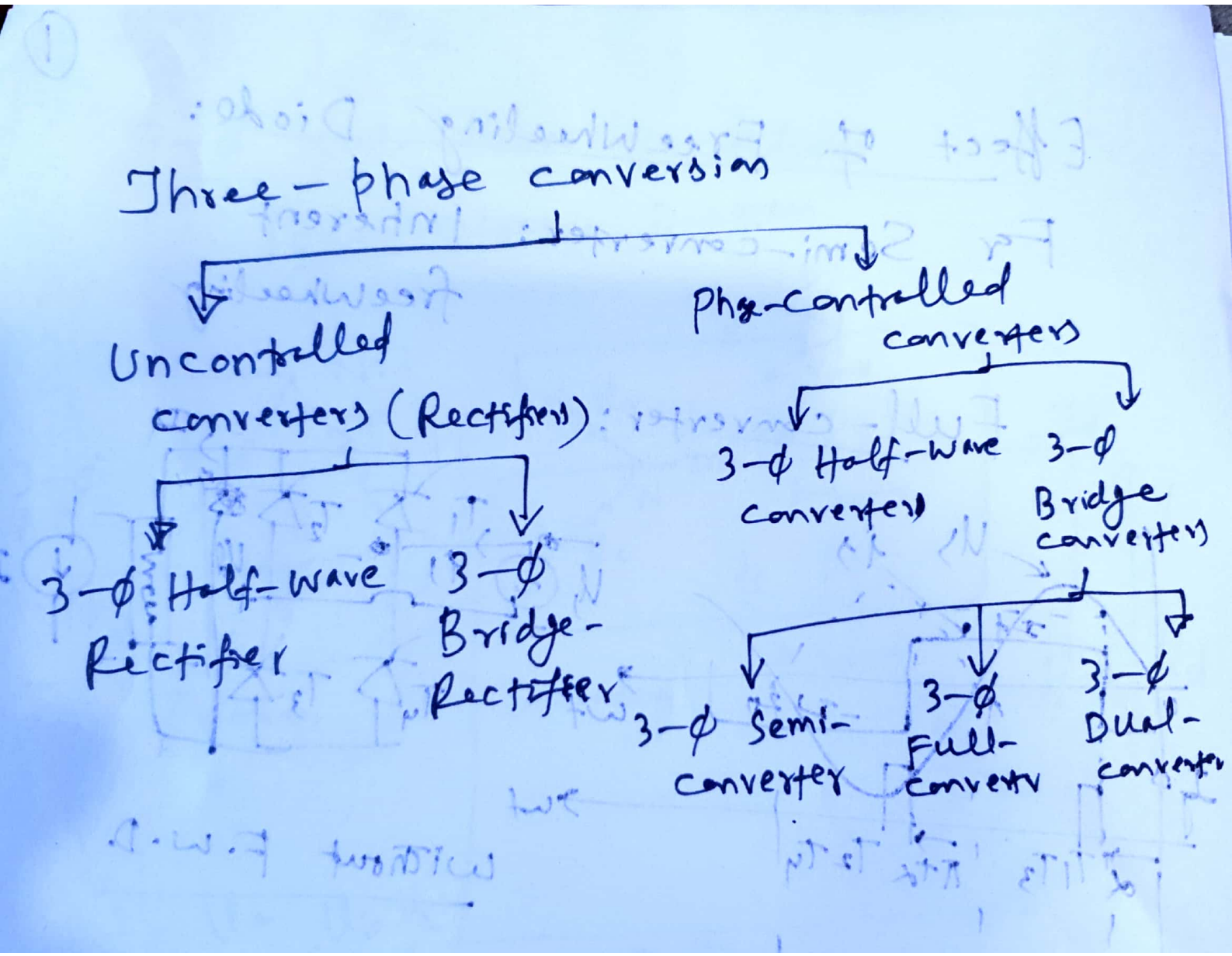


without F.W.D.



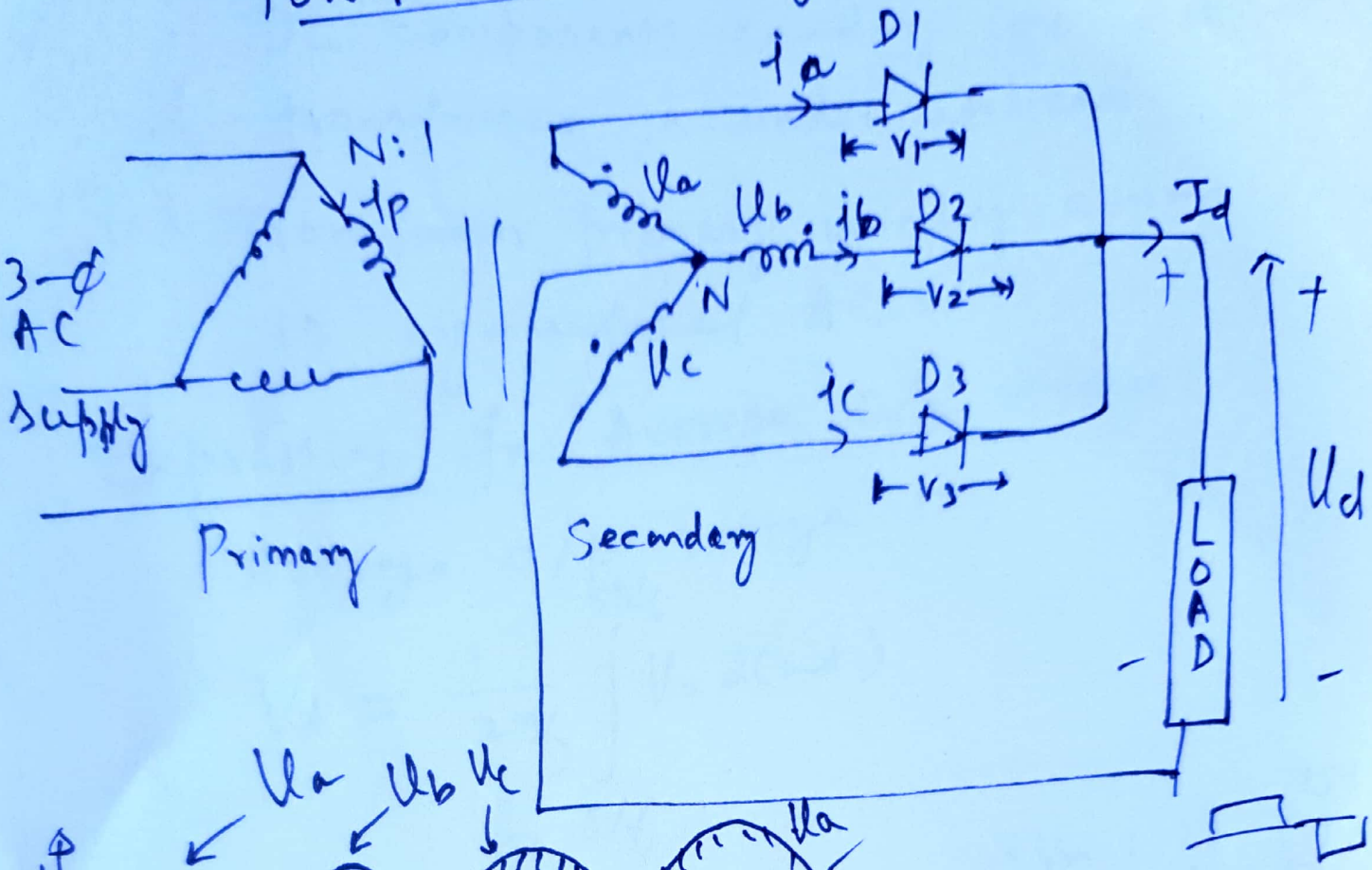
with F.W.D.

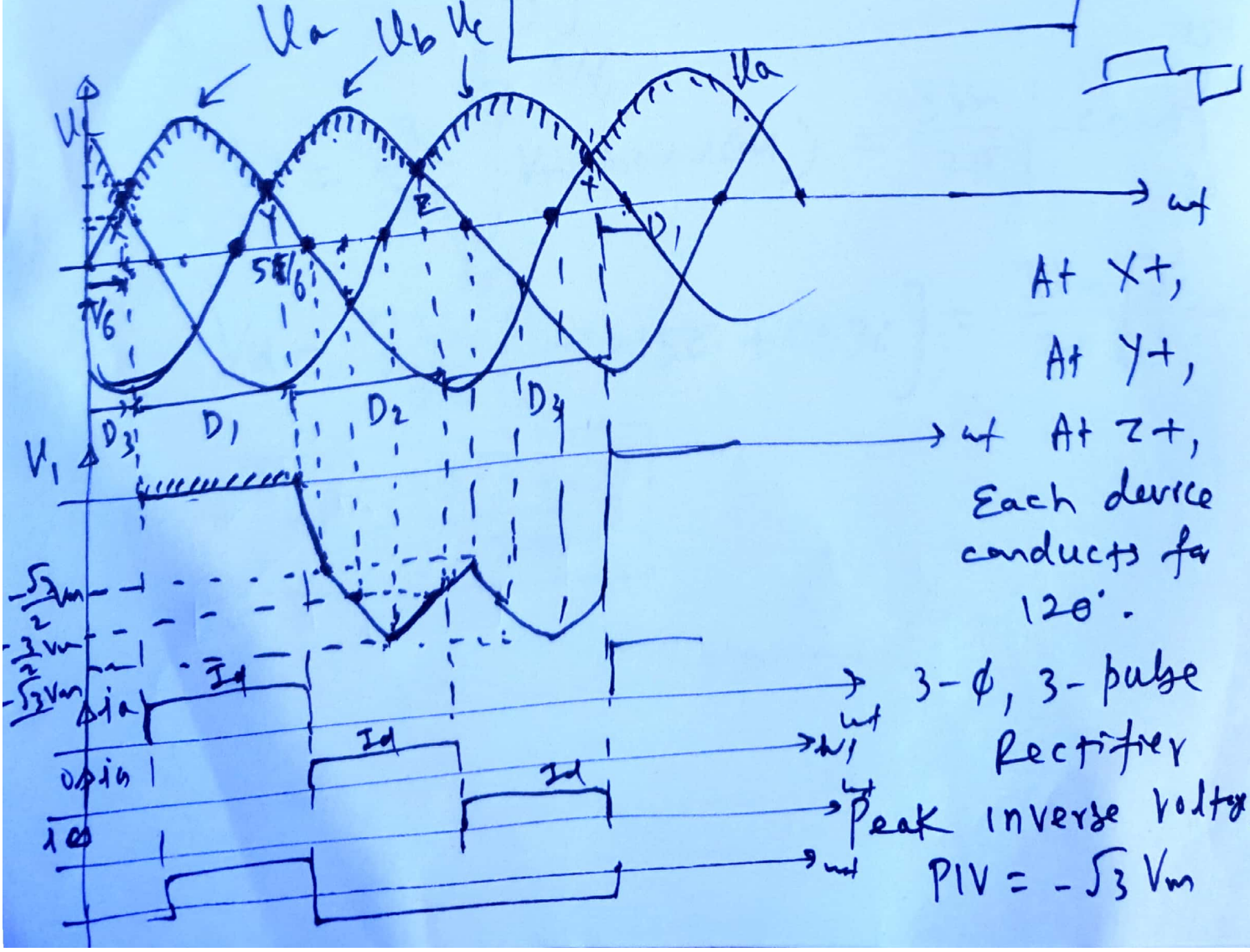




3-ϕ Half-Wave Rectifier:

Power circuit Diagram





Drawbacks: i) Transformer secondary winding currents contain strong DC components, leading to Saturation & transformer is under-utilized.

ii) Transformer primary winding current is asymmetrical AC.

Expression for Average O/P voltage..

Average O/P voltage is,

$$V_d = \frac{1}{2\pi/3}\int_{5\pi/6}^{\pi/6} V_m \, d(\omega t)$$

$$V_d = \frac{3}{2\pi}\int_{150}^{30} V_m \sin\omega t \, d(\omega t) = \frac{3V_m}{2\pi}\Big|-\cos\omega t\Big|_{30}^{150}$$

$$V_d = \frac{3V_m}{2\pi}\left[-\cos 150^\circ + \cos 30^\circ\right] = \frac{3V_m}{2\pi}\left[\frac{\sqrt{3}}{2} +\right.$$

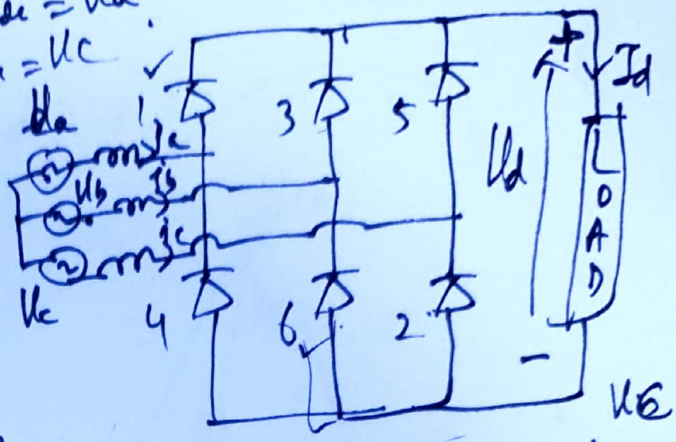
$$\Rightarrow \boxed{V_d = \frac{3\sqrt{3}V_m}{2\pi}}$$

3-ϕ Bridge Rectifier:

$V_{Anode} = V_a$

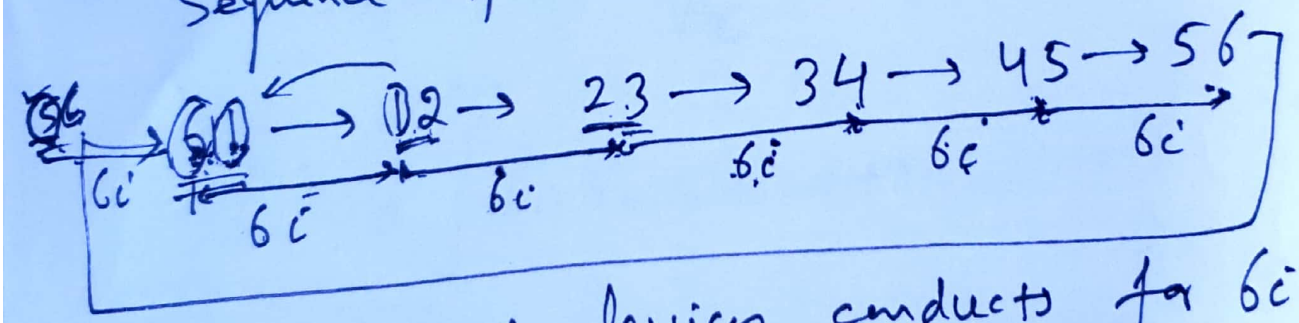
$V_{Cathode} = V_c$

$V_l = V_a - V_c = V_{ac}$



A device goes into conduction only when it's commutation voltage becomes positive (i.e., when it is forward-biased).

Sequence of conduction is as:



- Each pair of devices conducts for 60°.
- Each device conducts for 120°.

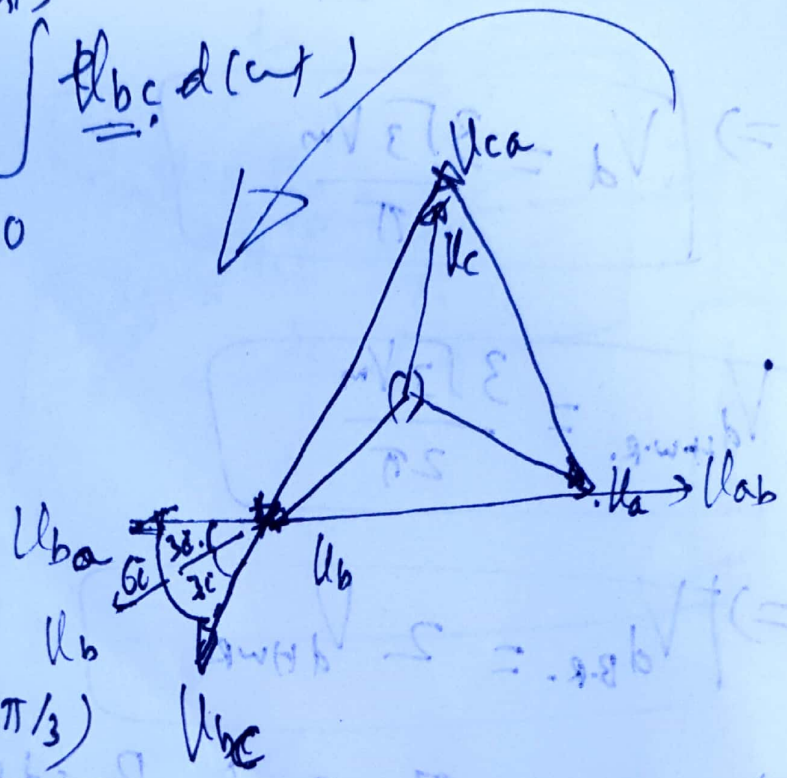
Device	Commutation voltage
1	V_{ac} =
2	V_{bc} =
3	V_{ba}
4	V_{ca}
5	V_{cb}
6	V_{ab}

→ 61 → 12 → 23 →
56 ← 45 ← 34

Expression for Average o/p voltage.

Average o/p voltage,

$$V_d = \frac{1}{\pi/3}\int_0^{\pi/3} V_{bc}\, d(\omega t)$$



Taking V_{ba} as reference.

$\therefore V_{ba} = \sqrt{3} V_m \sin \omega t$

$\therefore V_{bc} = \sqrt{3} V_m \sin(\omega t + \pi/3)$

$$\therefore V_d = \frac{3}{\pi}\int_0^{\pi/3} \sqrt{3} V_m \sin(\omega t + \pi/3)\, d(\omega t)$$

$$= \frac{3\sqrt{3} V_m}{\pi} \left| -\cos(\omega t + \pi/3) \right|_0^{\pi/3}$$

$$= \frac{3\sqrt{3} V_m}{\pi} \left[-\cos(\pi/3 + \pi/3) + \cos \pi/3 \right]$$

$$= \frac{3\sqrt{3} V_m}{\pi} \left[-\cos 2\pi/3 + \cos \pi/3 \right]$$

$$V_d = \frac{3\sqrt{3}\,V_m}{\pi}\left[\frac{1}{2}+\frac{1}{2}\right]$$

$$\Rightarrow \boxed{V_d = \frac{3\sqrt{3}\,V_m}{\pi}}$$

$$\boxed{V_{d_{HWR}} = \frac{3\sqrt{3}\,V_m}{2\pi}}$$

$$\Rightarrow \boxed{V_{d_{B.R.}} = 2\,V_{d_{HWR}}}$$

Advantages of 3-ϕ Bridge Rectifier:

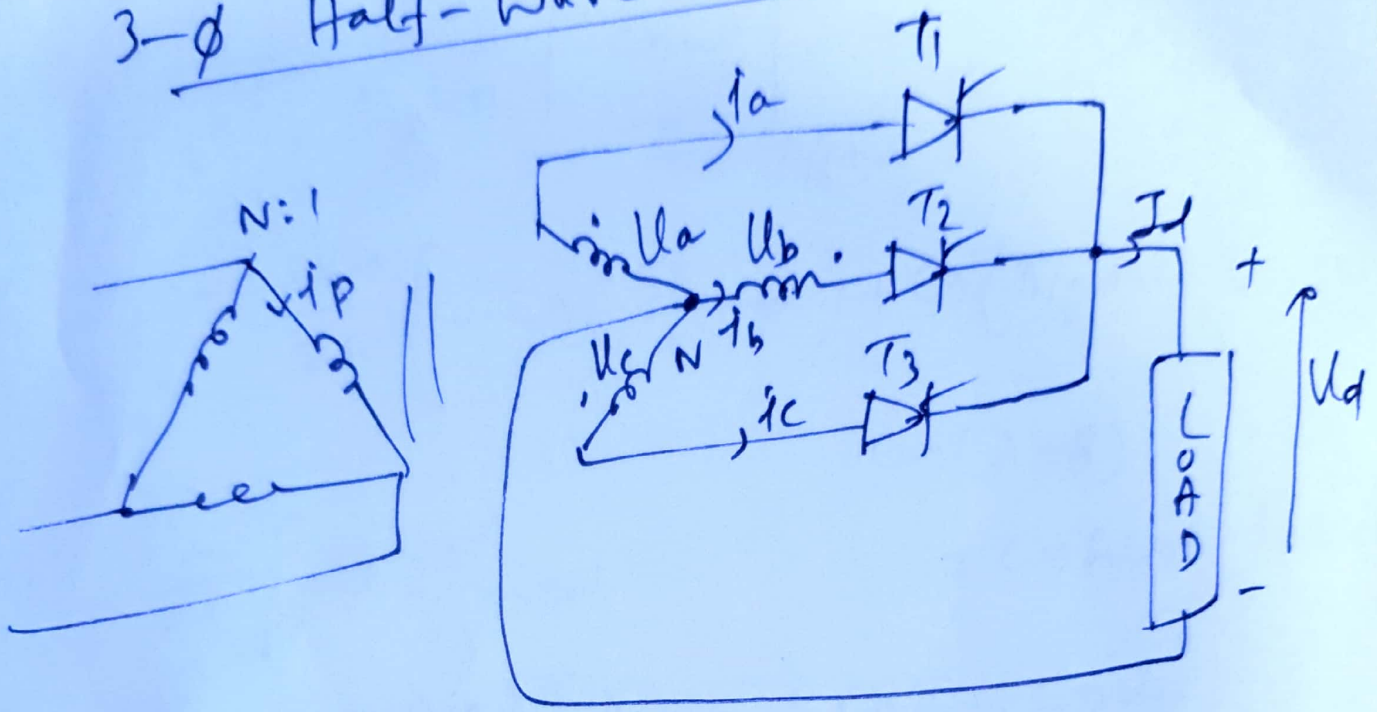
i) Av. o/p voltage is double that produced by 3-ϕ Half-wave Rectifier

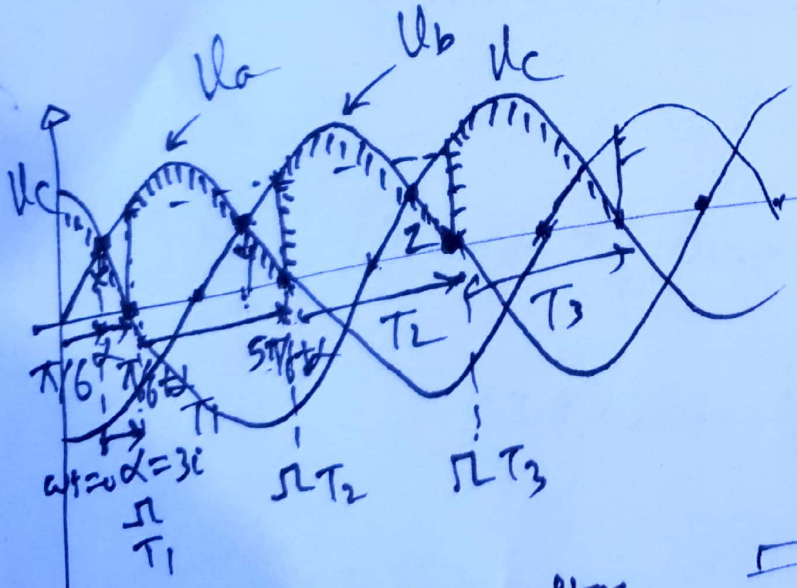
ii) Transformer secondary as well as primary currents are ~~ac~~ → No DC comp.

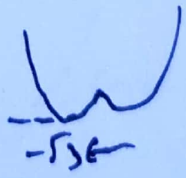
iii) No. transformer saturation & transformer utilization is better.

3-ϕ Phase-controlled converters:

3-ϕ Half-wave converters:



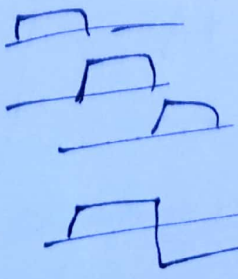




At ωt,

Va

PIV $= -\sqrt{3}E_m$



Each device is ON for $2\pi/3$ (120°)

Average o/p voltage,

$$V_d = \frac{1}{2\pi/3}\int_{\pi/6+\alpha}^{5\pi/6+\alpha} V_a\, d(\omega t)$$

$$V_d = \frac{3}{2\pi}\int_{\pi/6+\alpha}^{5\pi/6+\alpha} V_m \sin\omega t \, d(\omega t)$$

$$= \frac{3V_m}{2\pi}\Big|-\cos\omega t\Big|_{\pi/6+\alpha}^{5\pi/6+\alpha}$$

$$= \frac{3V_m}{2\pi}\left[-\cos\left(\frac{5\pi}{6}+\alpha\right)+\cos\left(\pi/6+\alpha\right)\right]$$

$\cos(A+B) = \cos A\cos B - \sin A\sin B$

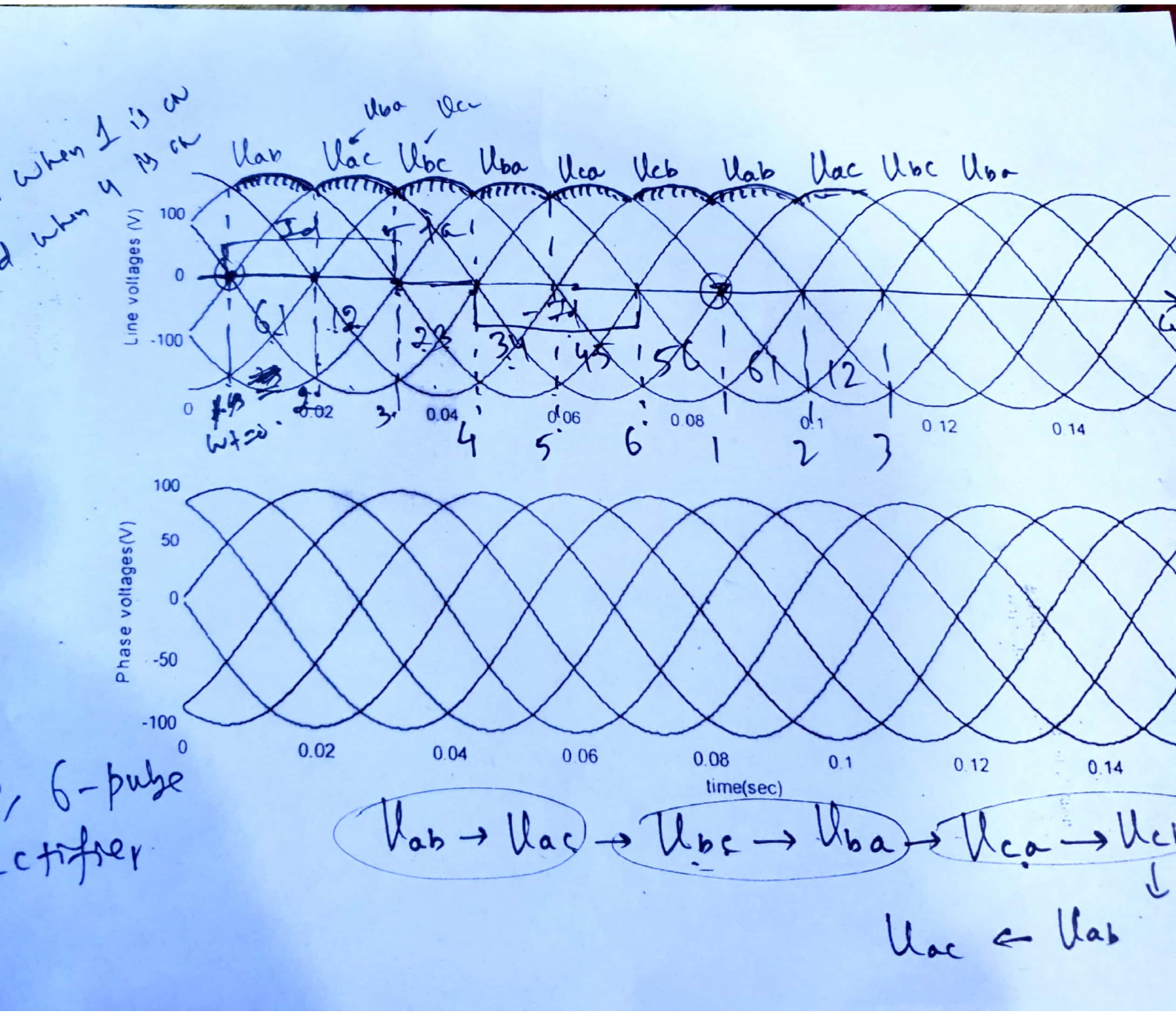
$$V_d = \frac{3V_m}{2\pi}\left[-\cos\frac{5\pi}{6}\cdot\cos\alpha + \sin\frac{5\pi}{6}\sin\alpha + \cos\pi/6\cdot\cos\alpha - \sin\pi/6\cdot\sin\alpha\right]$$

$$= \frac{3V_m}{2\pi}\left[\frac{\sqrt{3}}{2}\cos\alpha + \frac{1}{2}\sin\alpha + \frac{\sqrt{3}}{2}\cos\alpha - \frac{1}{2}\sin\alpha\right]$$

$$\therefore \boxed{V_d = \frac{3\sqrt{3}V_m}{2\pi}\cos\alpha}$$

At $\alpha = 0$,

$\cos\alpha = \cos 0 = 1$



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