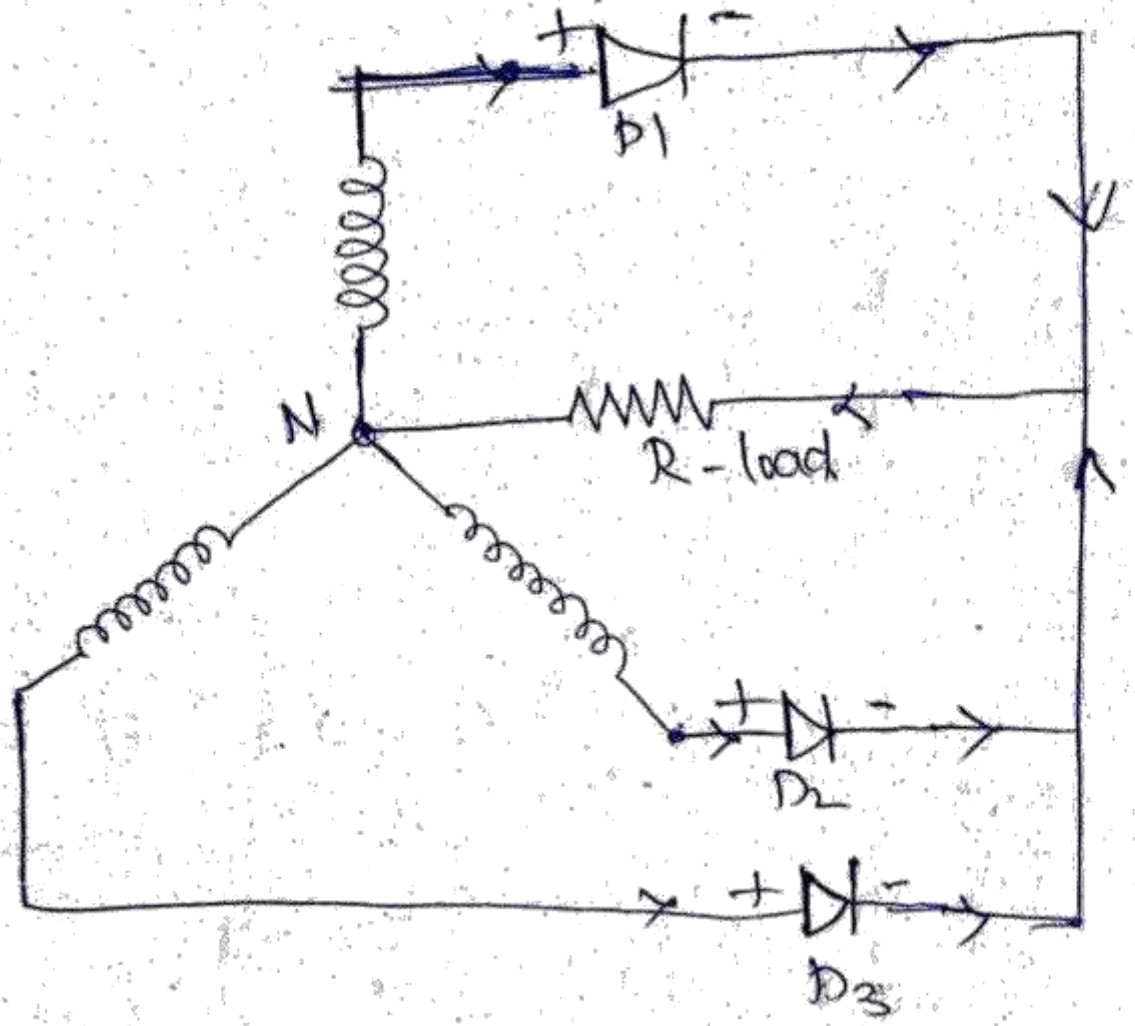
17/08/19

UNIT-3. Three phase Rectifier

* 3-ϕ Half Wave Rectifier With R-load:

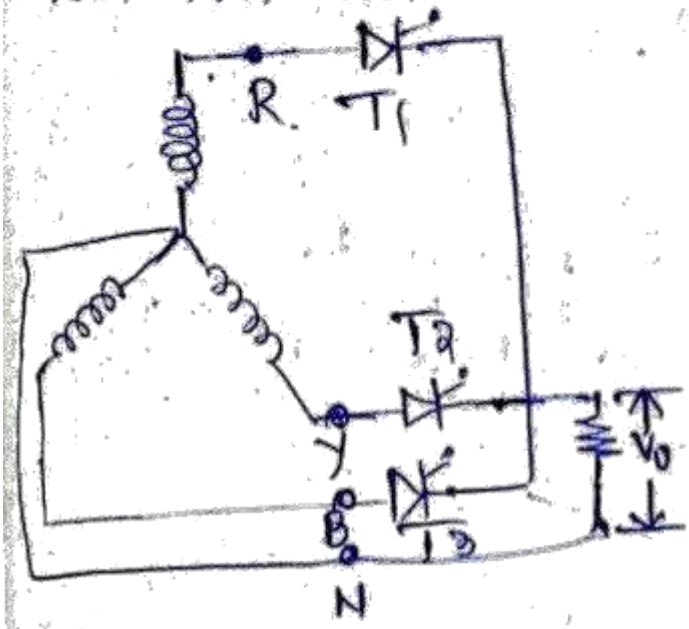


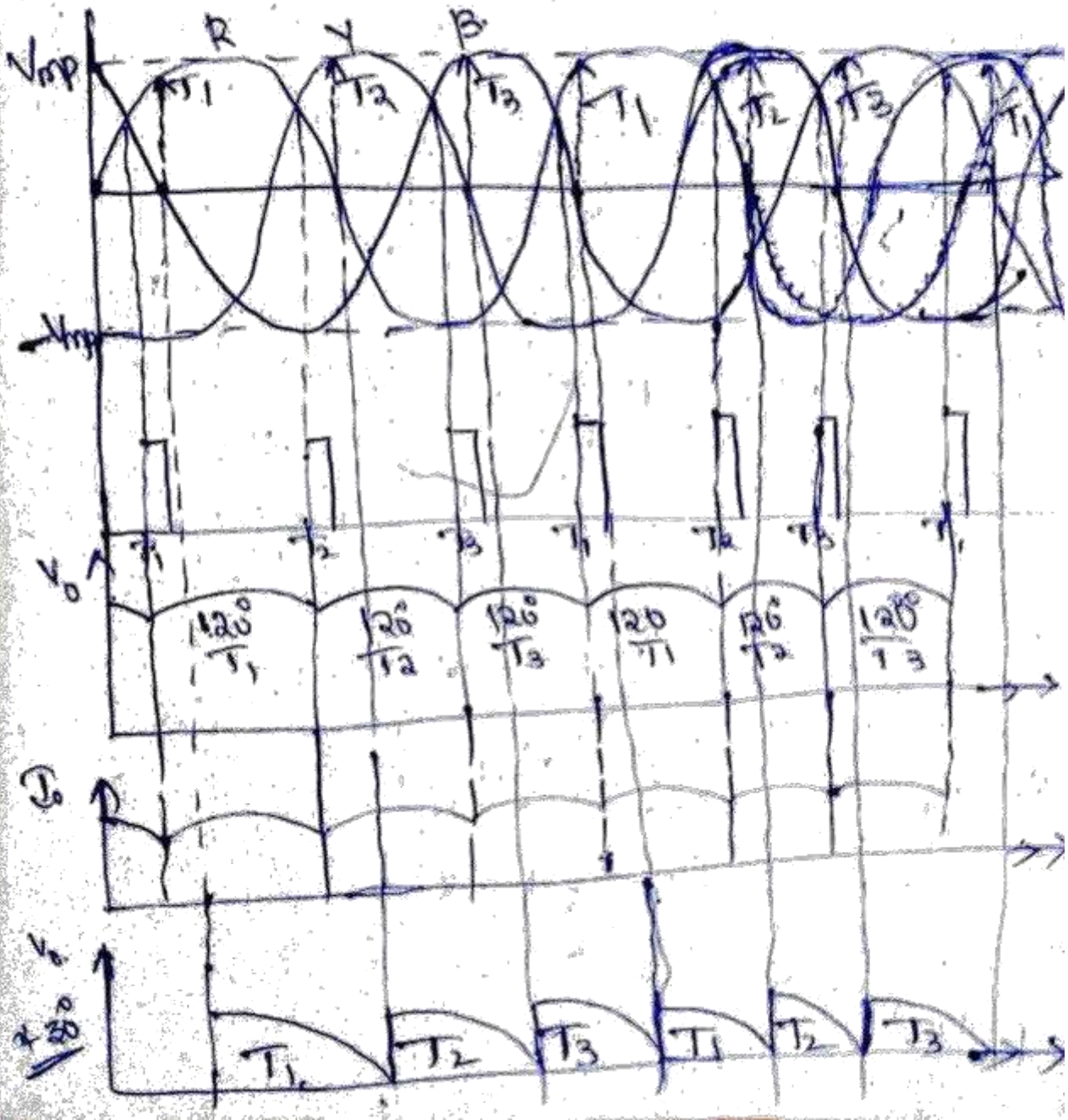
→ Each angle is displaced by 120°.

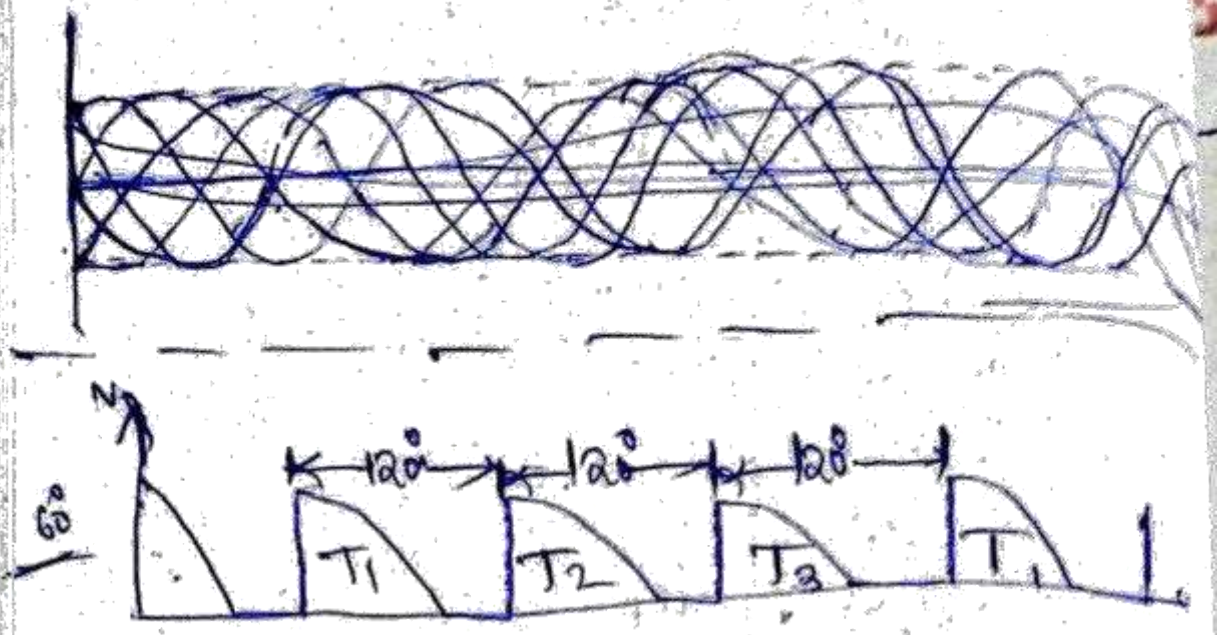
→ There is no voltage drop.

21/08/19

3-ϕ Half Wave Converter With R-load :-







22/08/19

$$0 \le \alpha \le 30^\circ$$

for Continuous Current Mode :-

$$V_{orms} = \left[\frac{3}{2\pi}\int_{\pi/6+\alpha}^{\pi/6+\alpha} V_{mp}^2 \sin^2 \omega t \, d\omega t\right]^{1/2}$$

$$= \frac{3V_{mp}^2}{4\pi}\left[\omega t\right]_{\alpha+\pi/6}^{\alpha+\pi/6} - \left[\frac{\sin 2\omega t}{2}\right]_{\alpha+\pi/6}^{\alpha+\pi/6}\Bigg]^{1/2}$$

$$= \frac{3V_{mp}^2}{4\pi}\left[\frac{2\pi}{3} + \frac{\sqrt{3}}{2}\cos\alpha\right]^{1/2}$$

$$= V_{mp}\left[\frac{1}{2} + \frac{3\sqrt{3}}{8\pi}\cos 2\alpha\right]^{1/2}$$

$$V_{orms} = \sqrt{3}\, V_{mp}\left[\frac{1}{6} + \frac{\sqrt{3}}{8\pi}\cos 2\alpha\right]^{1/2}$$

$$= V_{mL}\left[\frac{1}{6} + \frac{\sqrt{3}}{8\pi}\cos 2\alpha\right]^{1/2}$$

$$I_{orms} = \frac{V_{orms}}{2}$$

for Discontinuous Current Mode :-

$30^\circ \le \alpha \le 180^\circ$.

$$V_0 = \frac{3}{2\pi}\int_{\pi/6+\alpha}^{\pi} V_{mp}\sin\omega t\, d\omega t$$

$$V_0 = \frac{3V_{mp}}{2\pi}\left[1+\cos(\alpha+30^\circ)\right].$$

$$V_{orms} = \left[\frac{3}{2\pi}\int_{\pi/6+\alpha}^{\pi} V_{mp}^2 \sin^2\omega t\, d\omega t\right]^{1/2}.$$

$$= \frac{\sqrt{3}V_{mp}}{2\sqrt{\pi}}\left[\left(\left(5\pi/6-\alpha\right)+\tfrac{1}{2}\sin\left(2\alpha+\pi/3\right)\right)\right]^{1/2}.$$

$$= \frac{V_m}{2\sqrt{\pi}}\left[\left(5\pi/6-\alpha\right)+\tfrac{1}{2}\sin\left(2\alpha+\pi/3\right)\right]^{1/2}.$$

R-L load :-

Continuous :-

$$V_0 = \frac{3}{2\pi}\int_{\pi/6+\alpha}^{5\pi/6+\alpha} V_{mp}\sin\omega t\, d\omega t$$

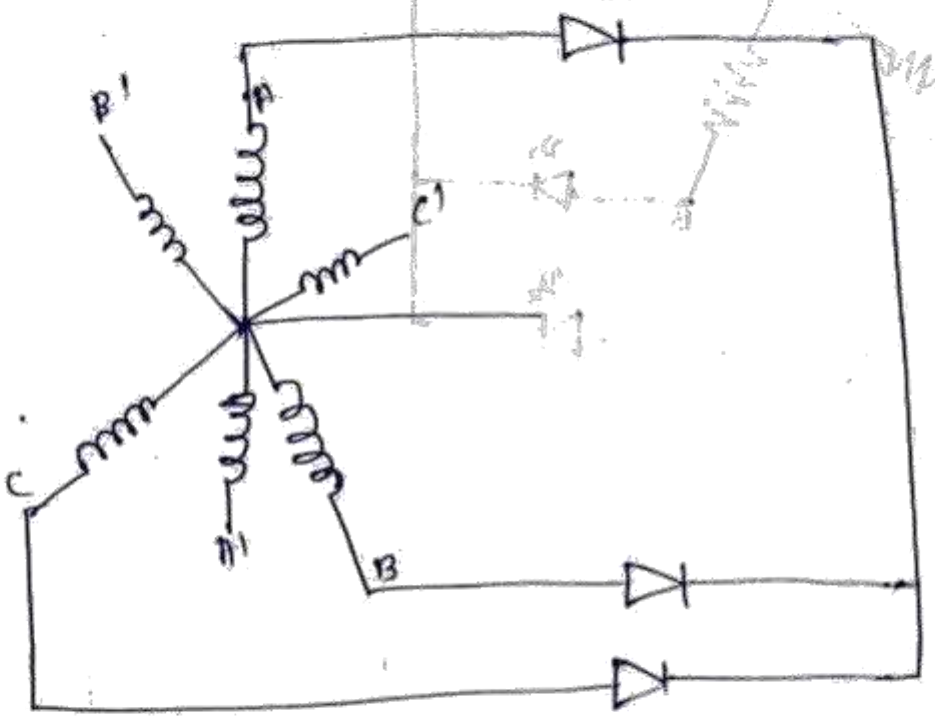
$$= \frac{3\sqrt{3}V_{mp}}{2\pi}\cos\alpha. \quad (or).$$

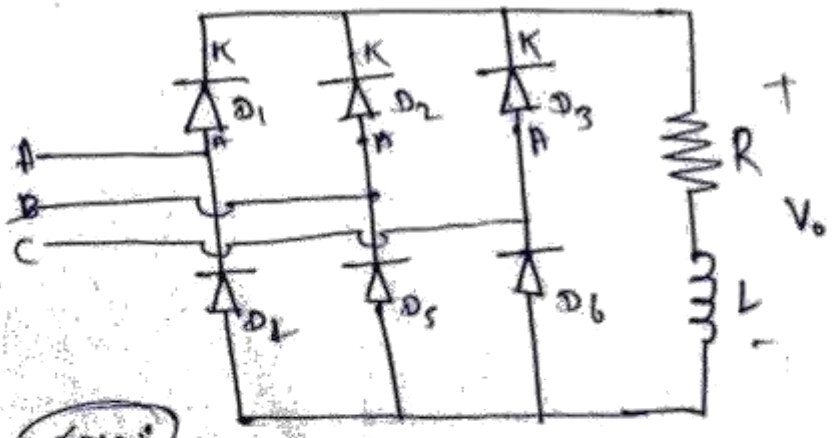
$$= \frac{3V_{rms}}{2\pi}\cos\alpha.$$

$$I_0 = V_0/R.$$

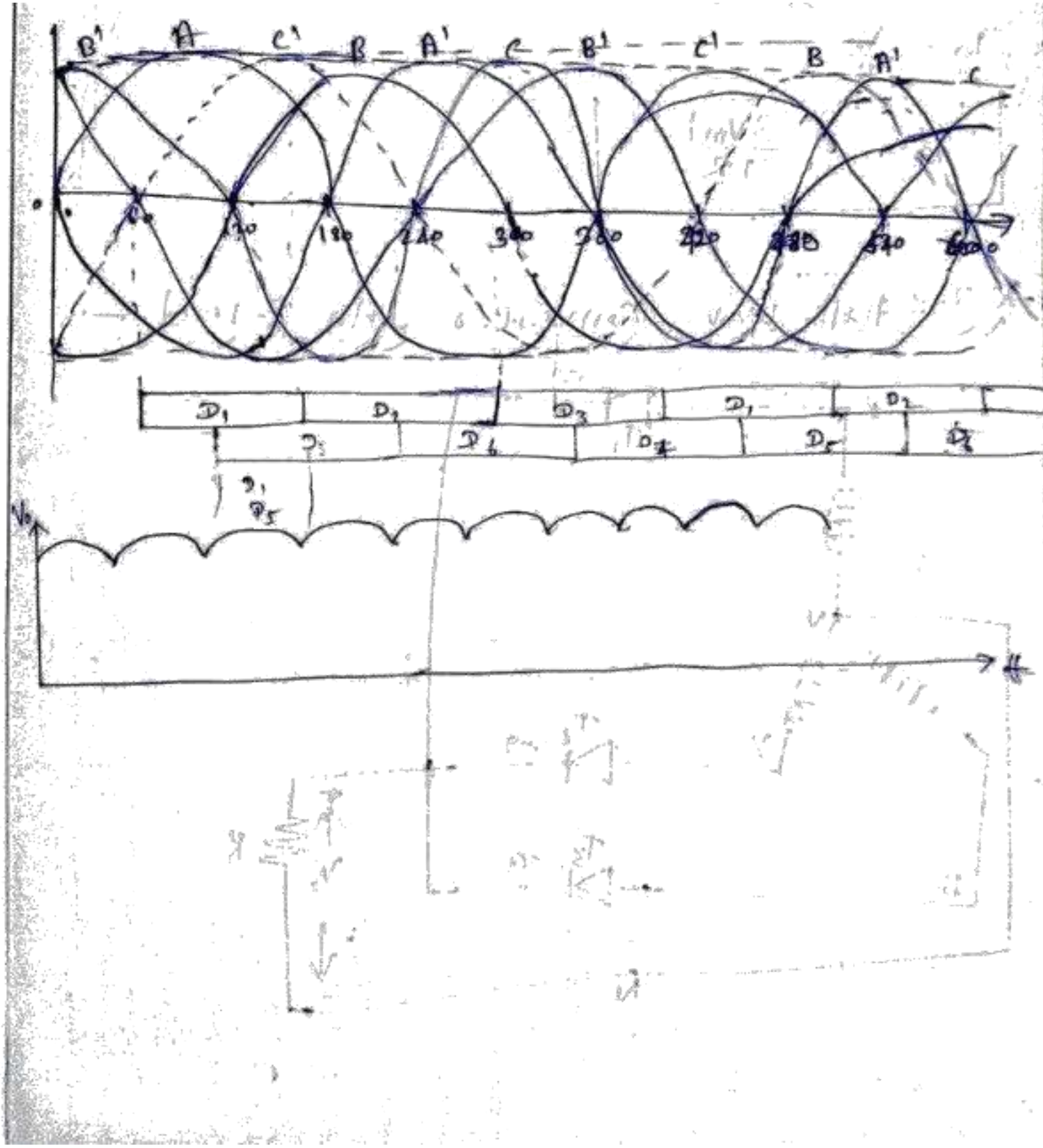
3-ϕ full wave ~~Converter~~ rectifiers:
(mid point conf)
i) Centertaped full wave rectifiers
ii) Bridgeten full wave rectifiers.

1) Mid point Configuration :-





Figure


B'
A
C'
B
A'
C
B'
C'
B
A'
C
0
60
120
180
240
300
360
420
480
540
600
D1
D2
D3
D4
D5
D6
V0
t

$$V_o = \frac{6}{2\pi}\int_{\pi/2}^{2\pi/3} V_{ml}\sin\omega t\, d\omega t$$

$$= \frac{6V_{ml}}{2\pi}\left[-\cos\omega t\right]_{\pi/3}^{2\pi/3} = \frac{3V_{ml}}{\pi}\left[\cos\left(\frac{2\pi}{3}\right) + \cos\frac{\pi}{3}\right]$$

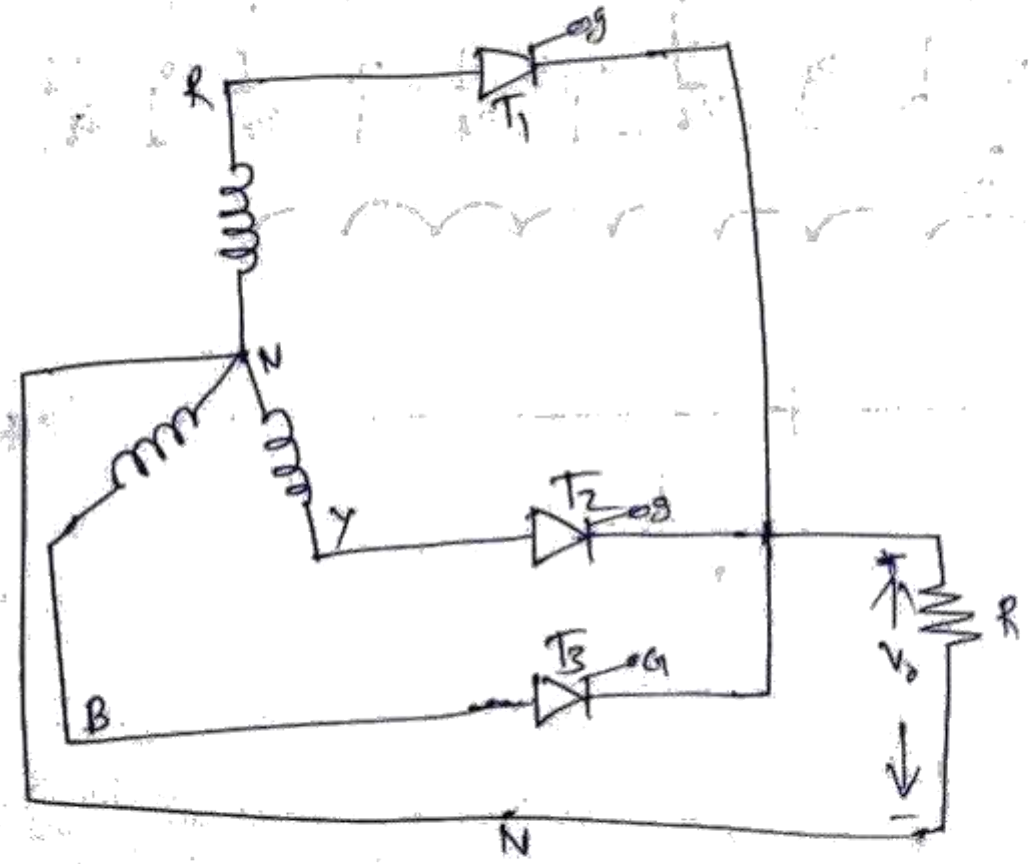
$$= \frac{3V_{ml}}{\pi}\left[\cos\frac{\pi}{3} + \cos\left[2\pi/3\right]\right]$$

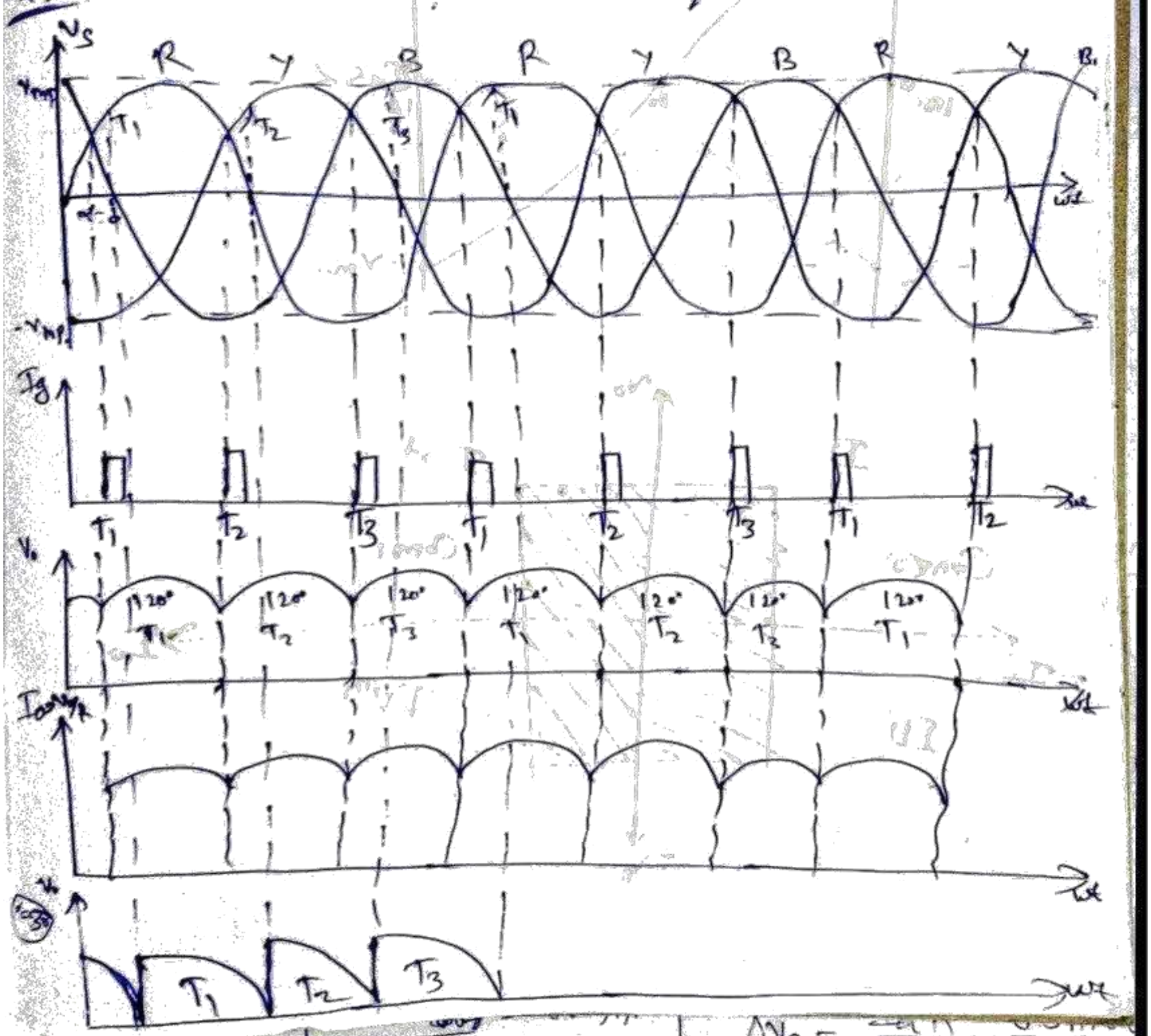
$$\boxed{V_o = \frac{3V_{ml}}{\pi}}$$

$$I_o = \frac{V_o}{R}$$

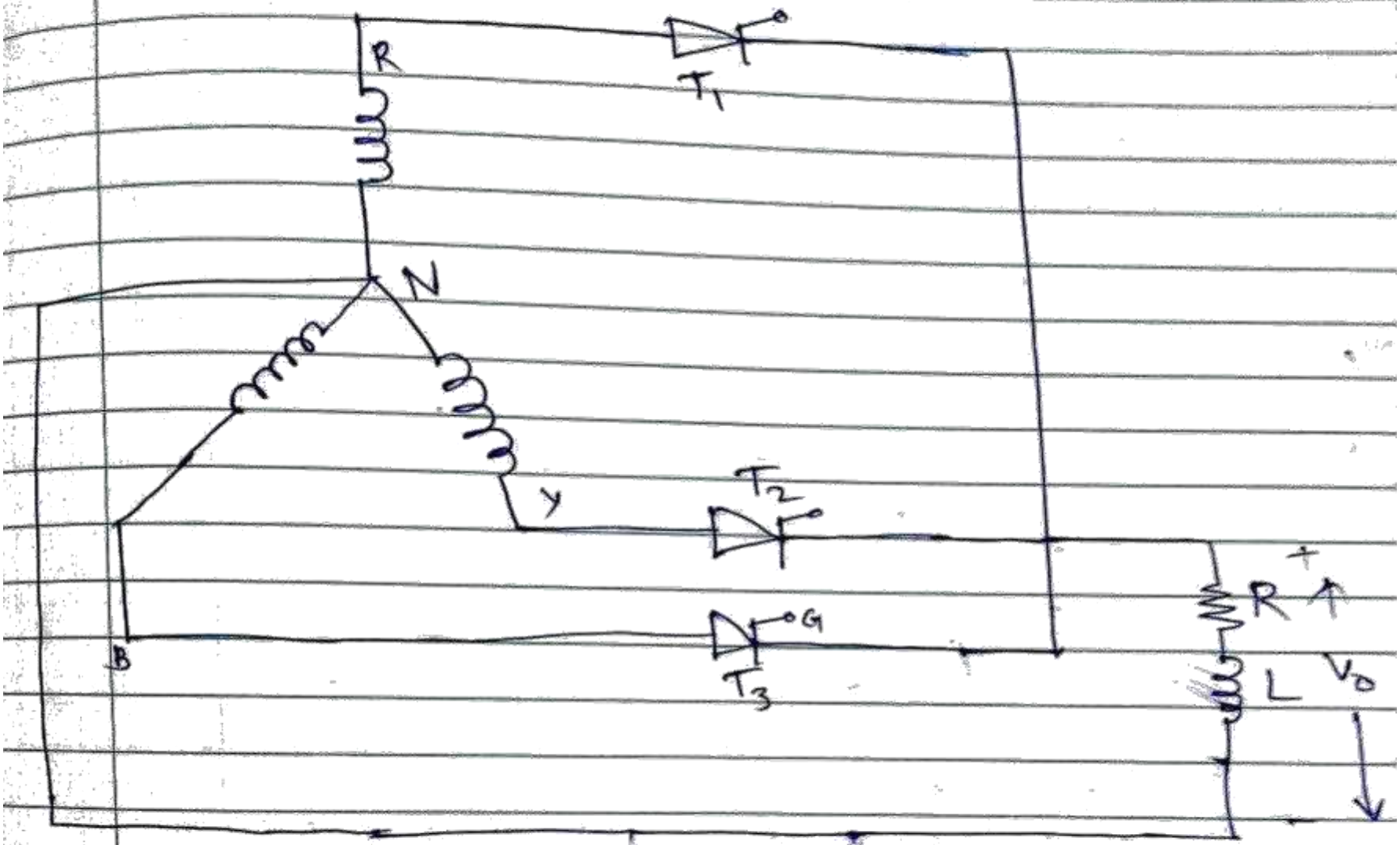
$$\boxed{I_o = \frac{3V_{ml}}{\pi R}}$$

* 3-ϕ Half wave Converter with R-Load :-



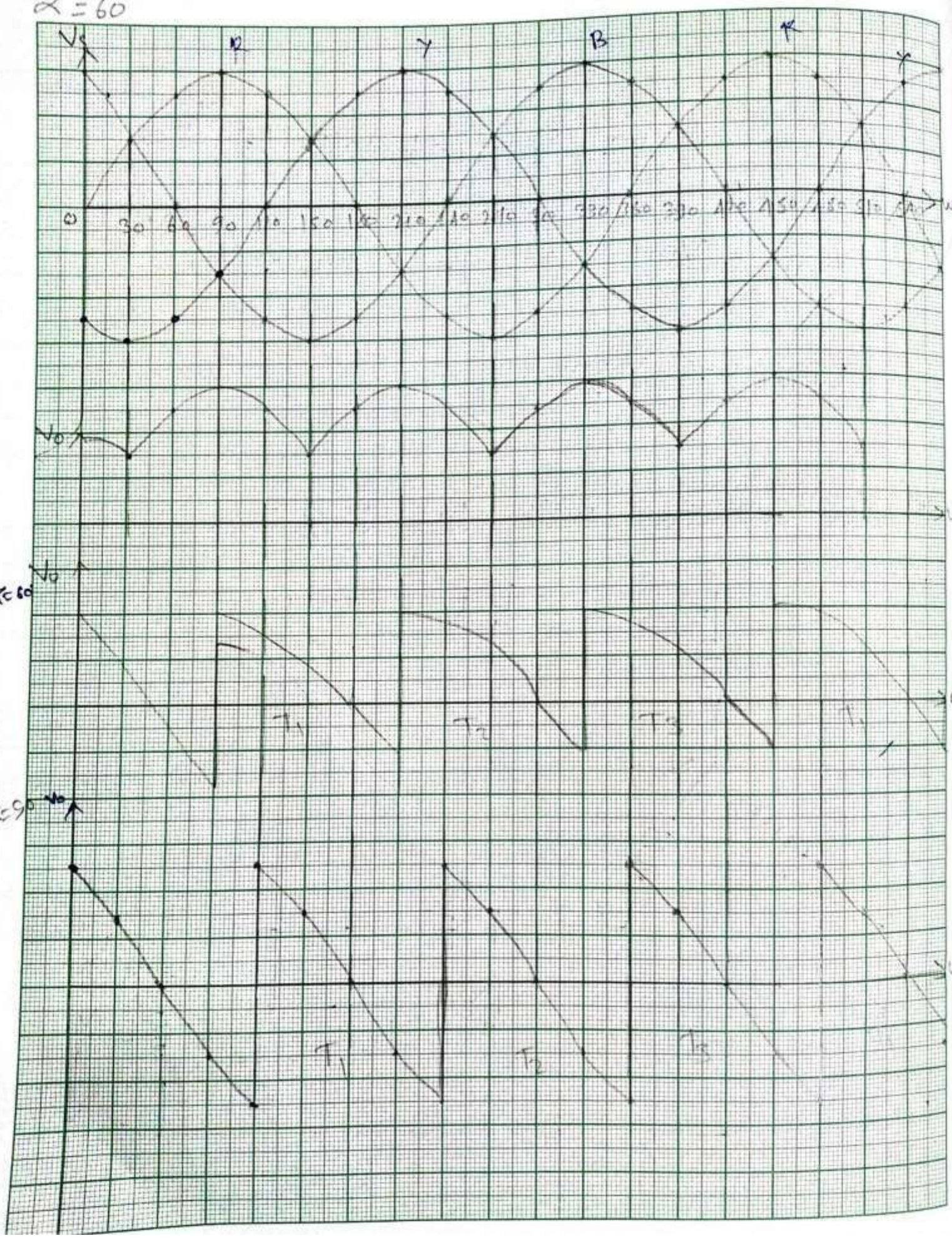

V_s
R
Y
B
R
Y
B
R
Y
B
T_1
T_2
T_3
T_1
ωt
I_g
T_1
T_2
T_3
T_1
T_2
T_3
T_1
T_2
V_o
120°
T_1
120°
T_2
120°
T_3
120°
T_1
120°
T_2
120°
T_3
120°
T_1
ωt
I_{load}
ωt
V_R
T_1
T_2
T_3
ωt

* 3-Ø half wave Converter with R-L Load :—



Teacher's Signature _____

$\alpha = 60$


Vs
R
Y
B
R
Y
0
30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480 510 540
ωt
Vo
ωt
$\alpha = 60$
Vo
T_1
T_2
T_1
T_2
ωt
$\alpha = 90$
Vo
T_1
T_2
T_1
T_2
ωt

Average o/p Voltage :-

$$V_o = \frac{3}{2\pi} \int_{\pi/6+\alpha}^{5\pi/6+\alpha} V_{mp} \sin\omega t \, d\omega t$$

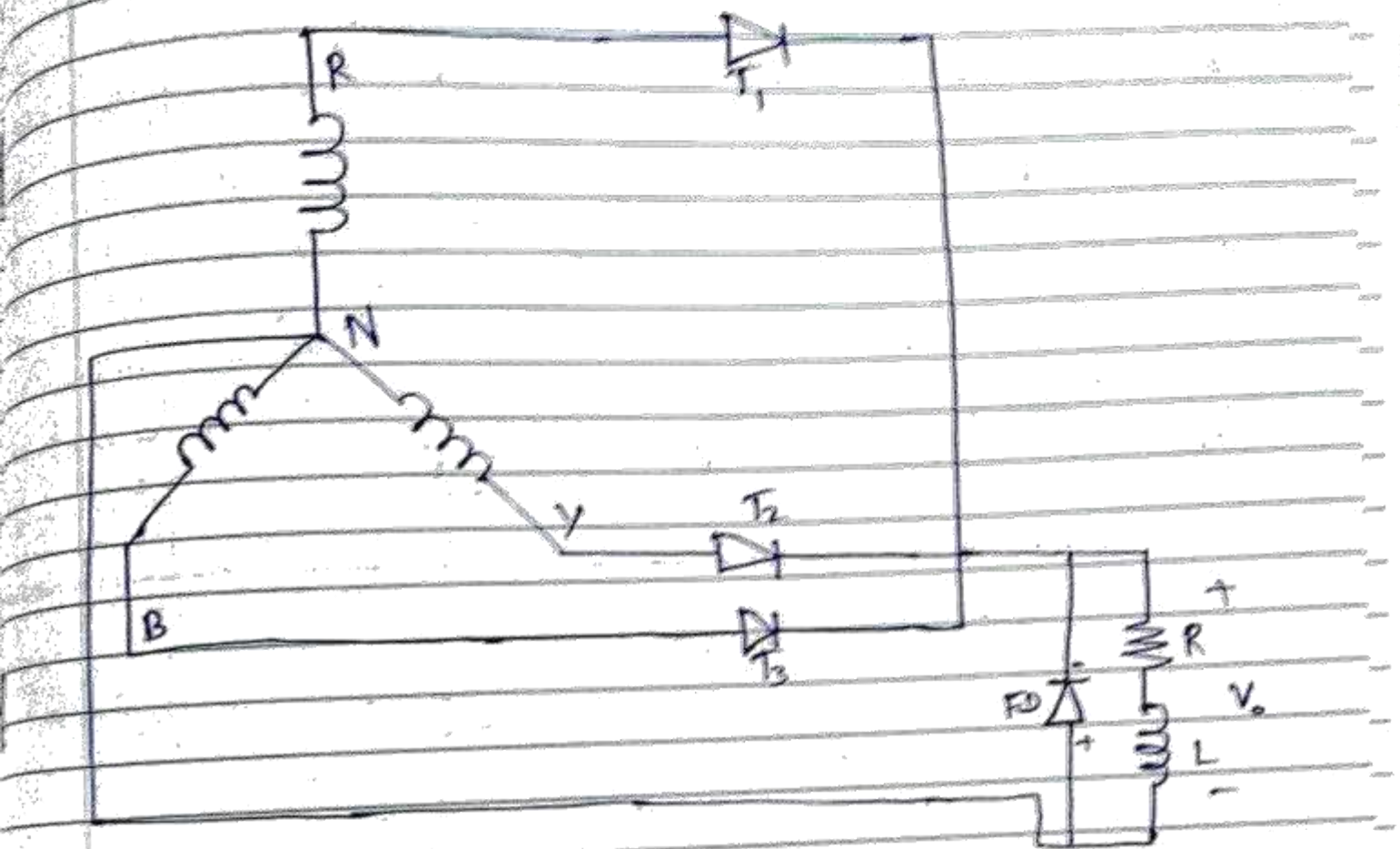
$$= \frac{3\sqrt{3}\, V_{mp} \cos\alpha}{2\pi} \text{ (or)}$$

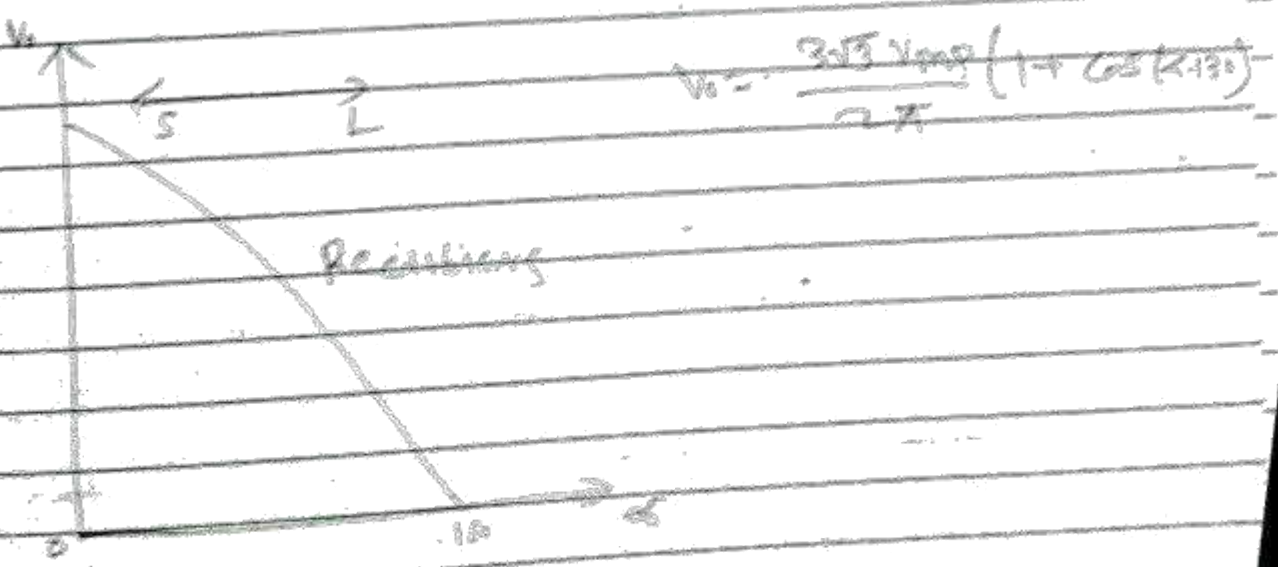
$$\boxed{V_o = \frac{3V_{ml}}{2\pi} \cos\alpha}$$

$$\boxed{I_o = \frac{V_o}{R}}$$

3-ϕ half wave converter with R-L Load with Free wheeling :-

Date

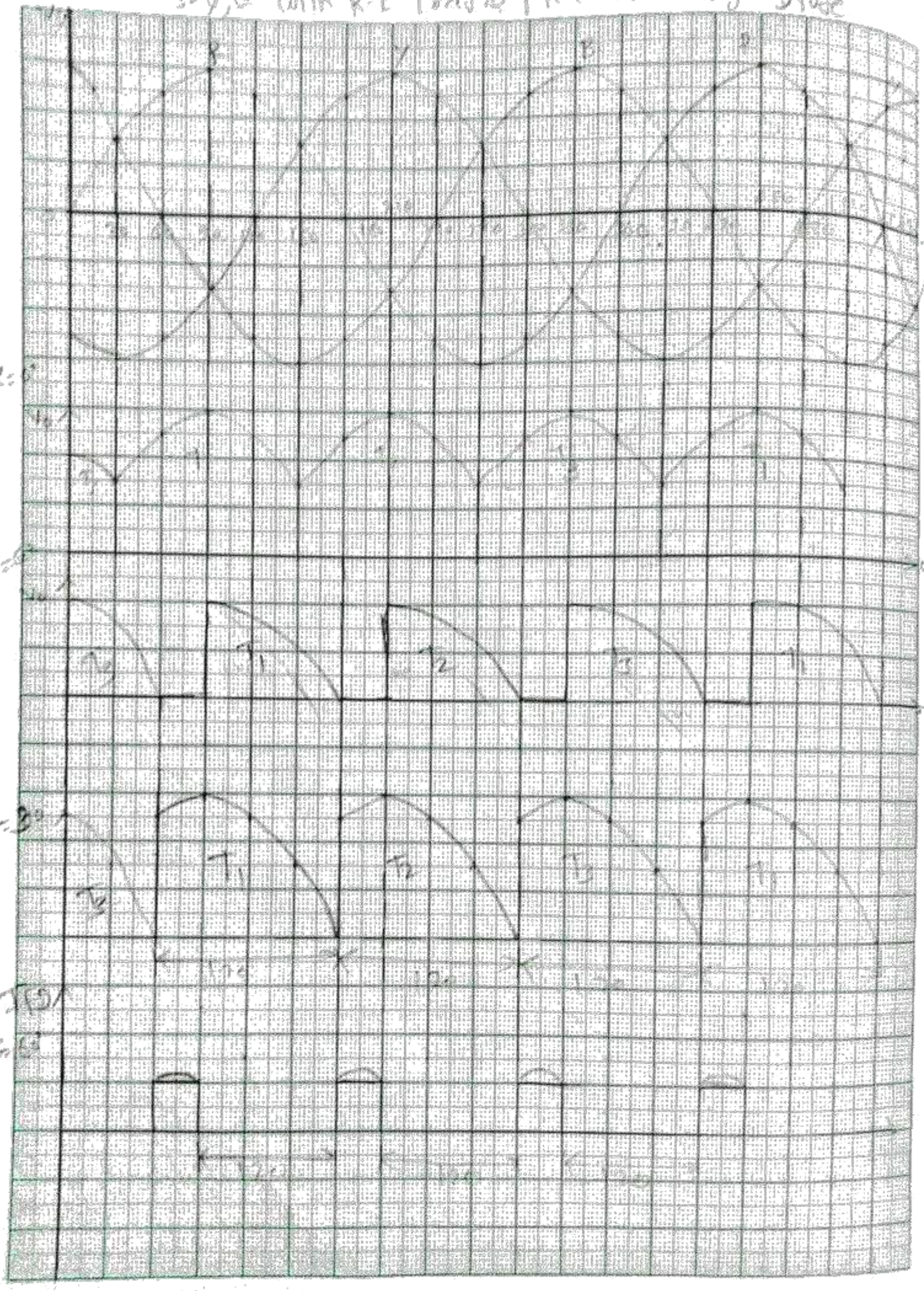




$$V_o = \frac{3\sqrt{3}\, V_{max}}{2\pi}\left(1 + \cos\left(\alpha + \frac{\pi}{3}\right)\right)$$

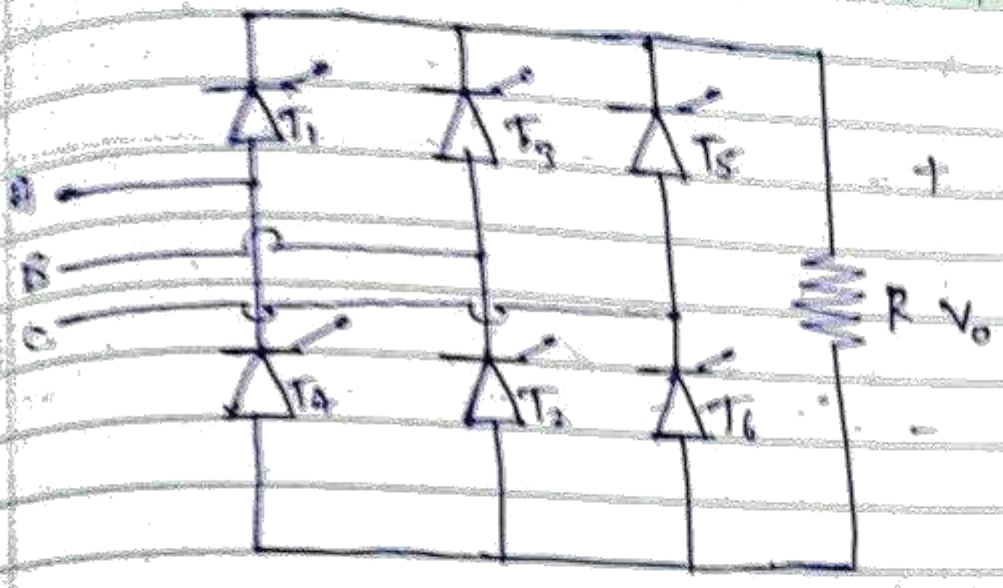
Teacher's Signature

3-ϕ, bridge with R-L load & free wheeling Diode



3-Φ Fully Controlled Converter with R Load:

Date



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

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

$$\boxed{V_o = \frac{3V_{ml}}{\pi}\cos\alpha}$$

$$\boxed{I_o = \frac{V_o}{R}}$$

$$V_{oRMS} = \left[\frac{6}{2\pi}\int_{\alpha+\pi/3}^{\alpha+2\pi/3} V_m^2 \sin^2\omega t\, d\omega t\right]^{1/2}$$

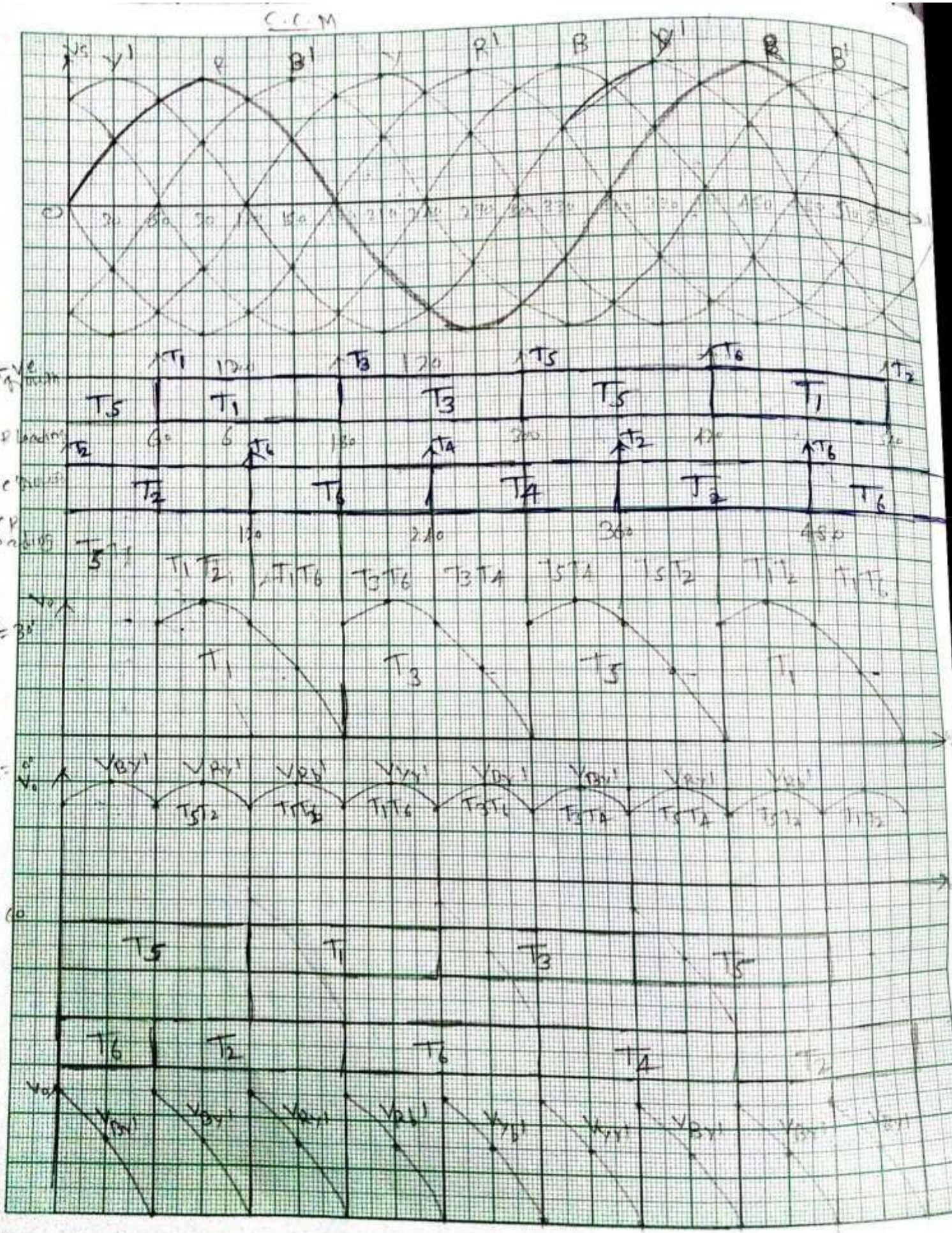
$$= \frac{\sqrt{3}\,V_{ml}}{\pi\sqrt{\pi}}\left[\int_{\alpha+\pi/3}^{\alpha+2\pi/3} \frac{1-\cos 2\omega t}{2}\, d\omega t\right]^{1/2}$$

$$= \frac{3V_{ml}}{4\sqrt{\pi}}\left[(\pi/3) - \frac{1}{2}\sin\alpha\right]^{1/2}$$

$$\boxed{I_o = \frac{V_{oRMS}}{R}}$$

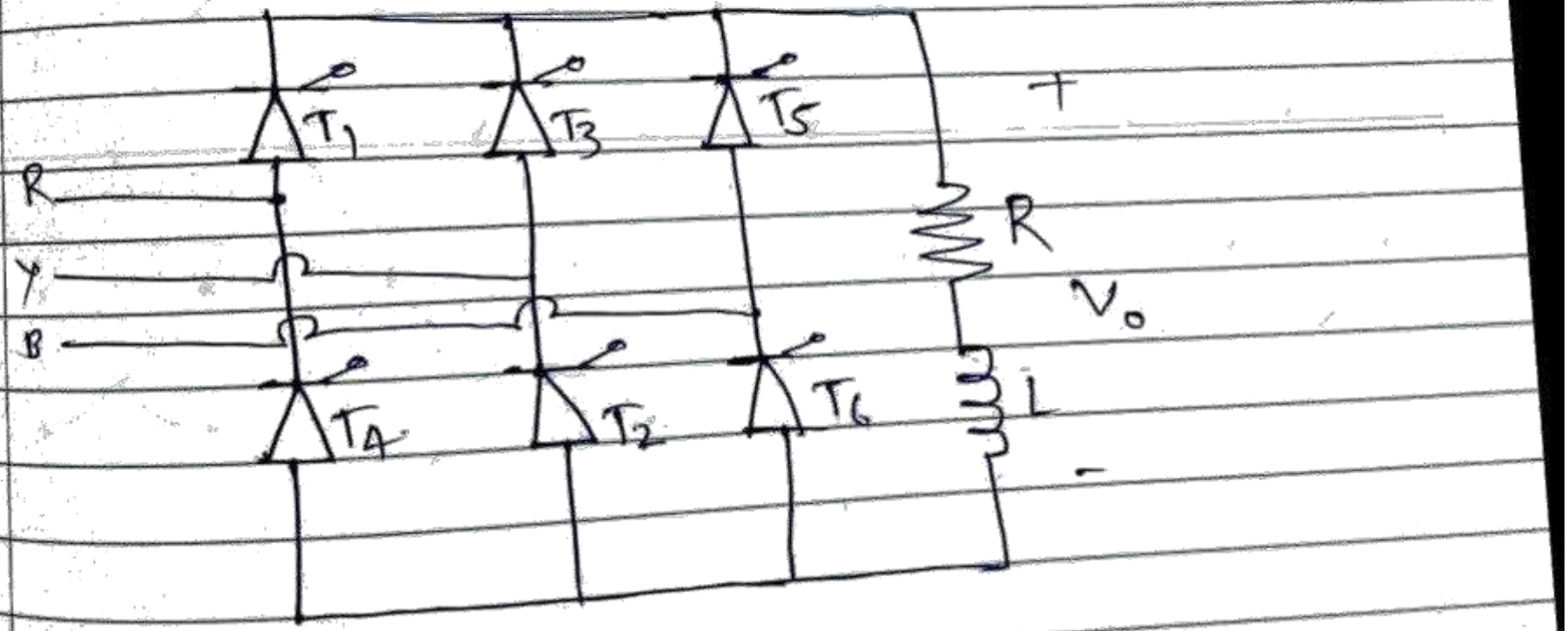
Teacher's Signature

C.C.M

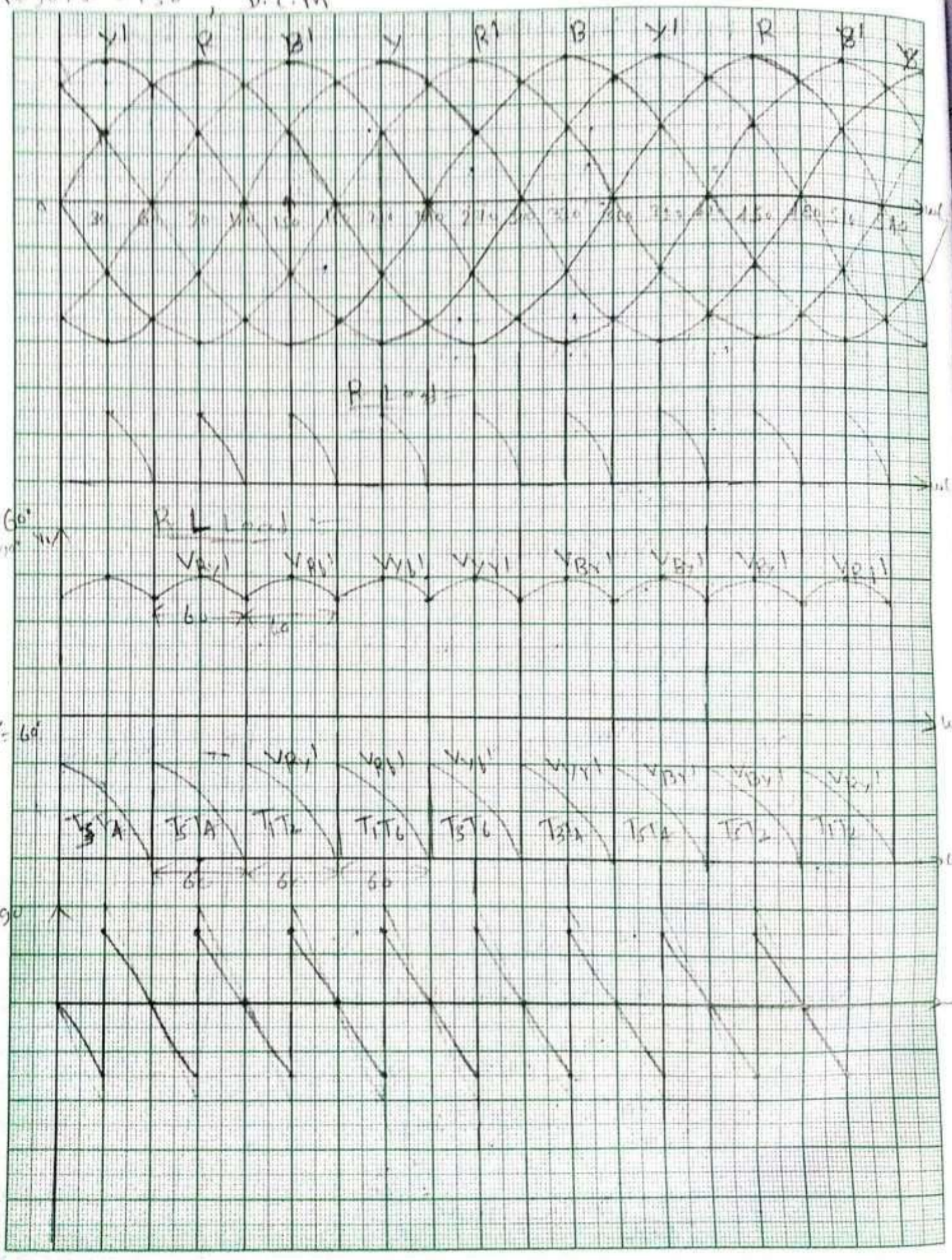

Vs
Y
R
B'
Y'
R'
B
Y
R
B'
T1
T3
T5
T6
T2
T5
T1
T3
T5
T1
T2
T6
T4
T2
T6
T2
T6
T4
T2
T6
T5T1
T1T2
T1T6
T2T6
T3T4
T5T4
T5T2
T1T2
T1T6
T1
T3
T5
T1
T5T2
T1T6
T2T6
T3T4
T5T4
T5T2
T1T2
T1T6
T5
T1
T3
T5
T6
T2
T6
T4
T2
Vo
VBY'
VRY'
VRB'
VYB'
VYR'
VBY'
VRB'
VRY'
VYB'
VYR'
VBY'

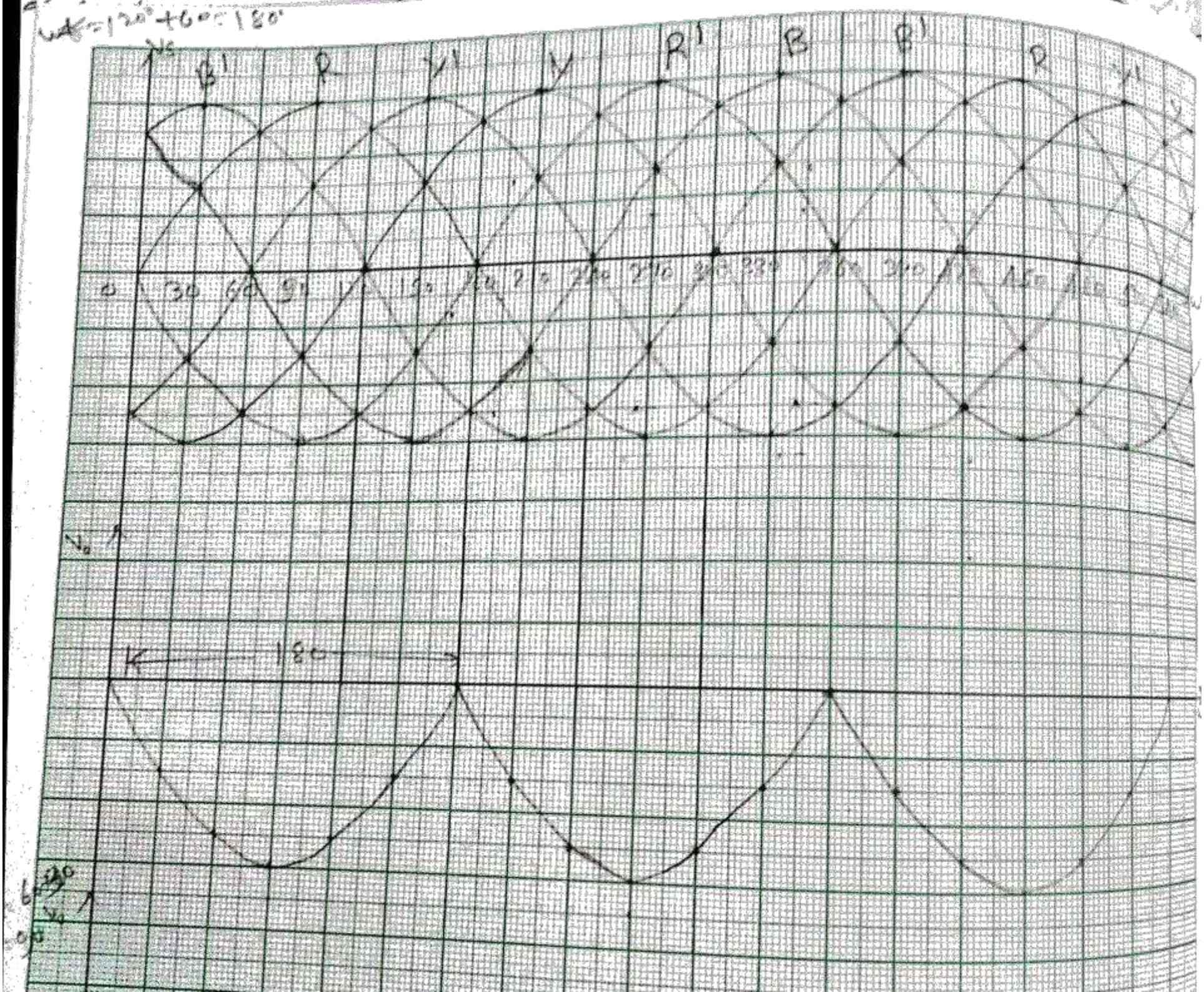
3-ϕ Fully Controlled Converter with R-L load

Date



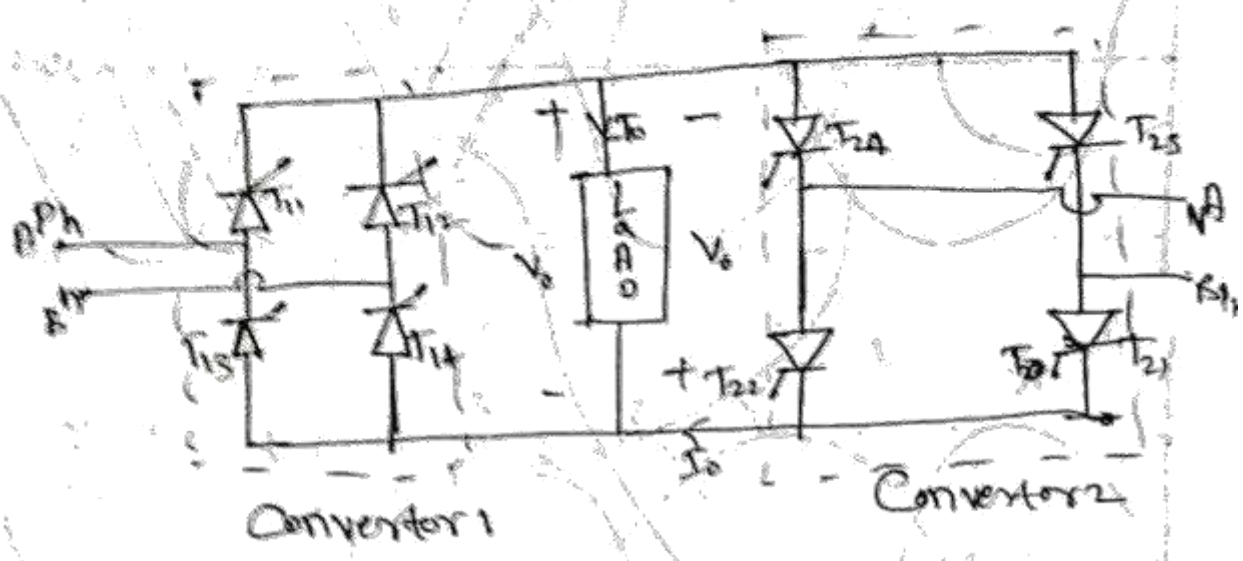
$\alpha = 30+60 = 150°$, D.C.M

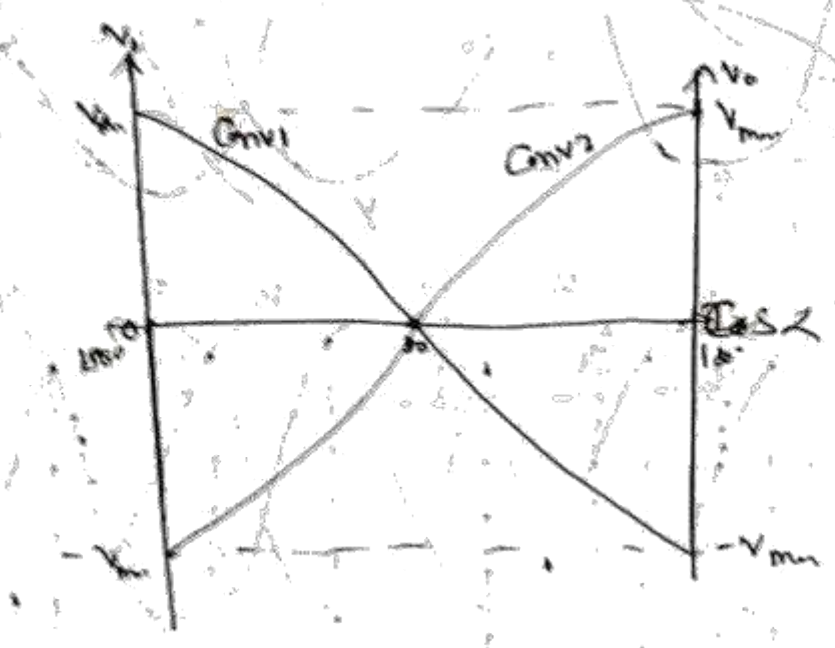


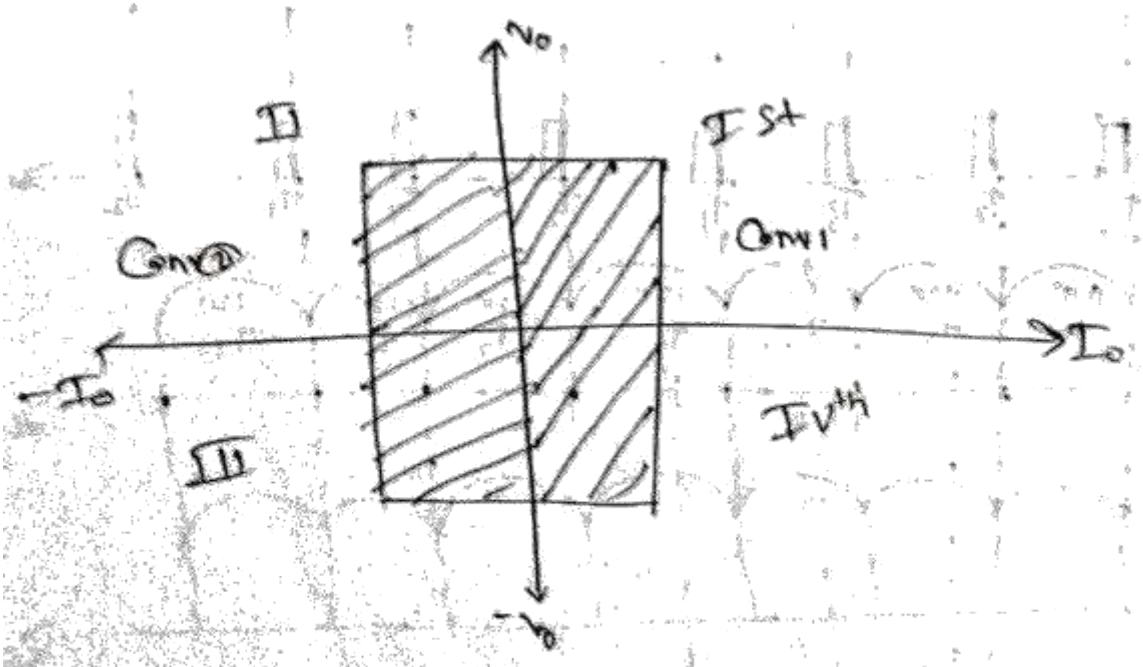

Y
B'
R
Y'
B
R'
K
180
120
60

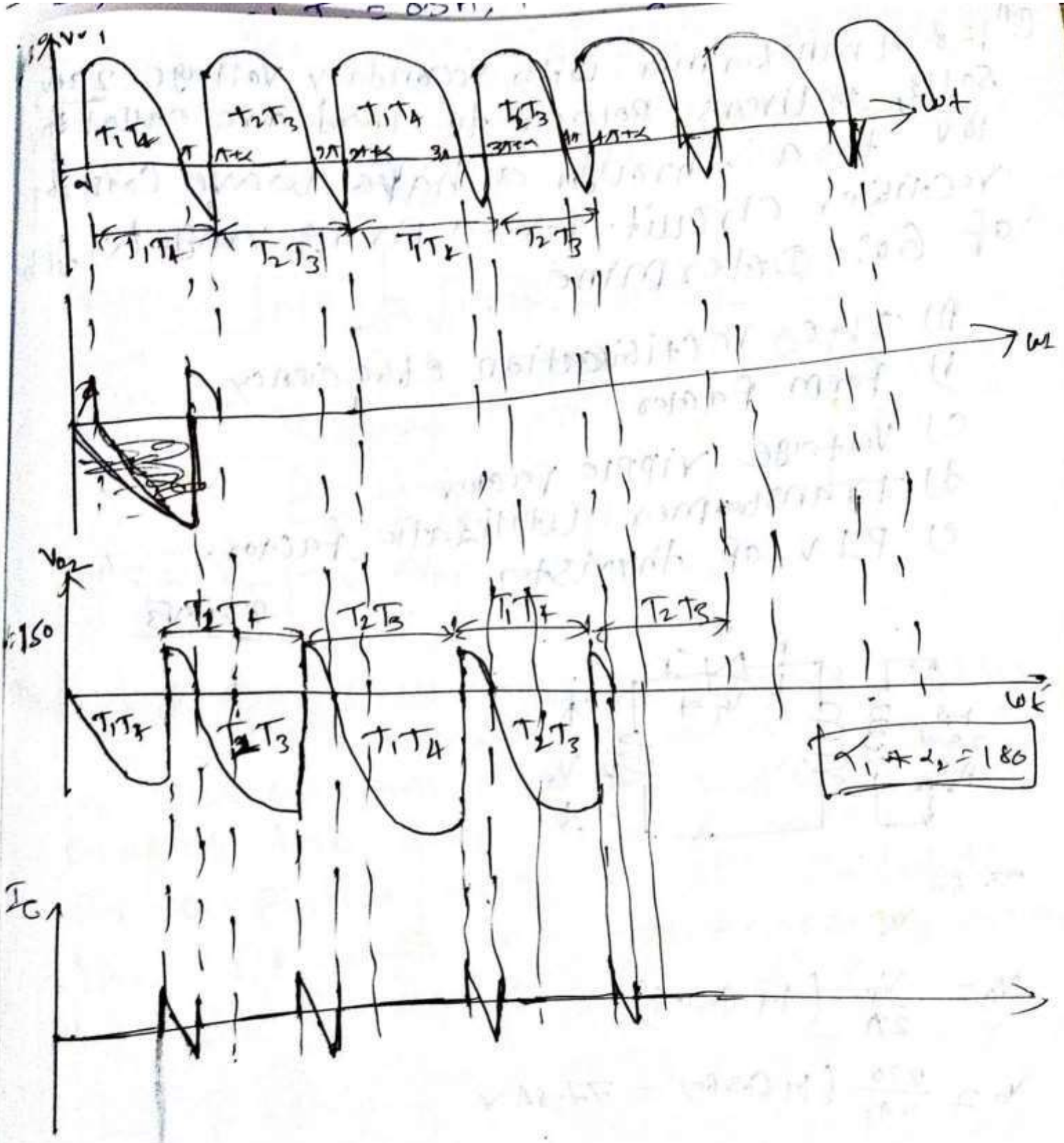
Dual Converter :-

1-ϕ (or) 3-ϕ Fully Controlled Converters



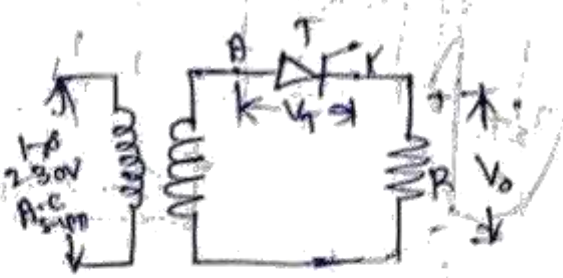





T_1T_4
T_2T_3
T_1T_4
T_2T_3
π
$\pi+\alpha$
2π
$2\pi+\alpha$
3π
$3\pi+\alpha$
4π
$4\pi+\alpha$
ωt
T_1T_4
T_2T_3
T_1T_4
T_2T_3
ωt
V_{o2}
150
T_2T_4
T_2T_3
T_1T_4
T_2T_3
T_1T_4
T_2T_3
T_1T_4
T_2T_3
ωt
$\alpha_1 + \alpha_2 = 180$
I_G

Q) 1-ϕ transformer with secondary voltage 230V, 50Hz, delivers power to load are equal to 10V to a through a half wave controlled rectifier circuit. For a firing angle delay of 60°. Determine

a) The rectification efficiency
b) Form factor
c) Voltage ripple factor
d) Transformer utilization factor.
e) PIV of thyristor.



$\alpha = 60$

$$V_o = \frac{V_m}{2\pi}(1+\cos\alpha)$$

$$V_o = \frac{230}{2\pi}(1+\cos 60) = 77.04\ V$$

$$I = \frac{V_o}{R} = \frac{77.04}{10} = 7.7\ A$$

Out put ac power $(P_{ac}) = V_{oRms} \times I_{orms}$

$$V_{oRms} = \frac{V_m}{2\sqrt{\pi}}\left[(\pi-\alpha)+\frac{1}{2}\sin 2\alpha\right]^{1/2}$$

$$= \frac{\sqrt{2}\times 230}{2\sqrt{\pi}}\left[(\pi-\pi/3)+\frac{1}{2}\sin 120\right]^{1/2}$$

$$= 145.86\ V$$

$$I_{orms} = \frac{V_{oRms}}{R} = \frac{145.86}{10} = 14.58\ A$$

$$P_{ac} = 145.86 \times 14.58 = 602.5\ W$$

$\eta_f = \frac{P_{dc}}{P_{ac}} = \frac{V_o I_o}{V_{orms} I_{orms}} = \frac{602.86}{2127.8} = 0.283 = 28.33\%$

form factor $= \frac{V_{oRms}}{V_o} = \frac{145.87}{77.64} = 1.879$

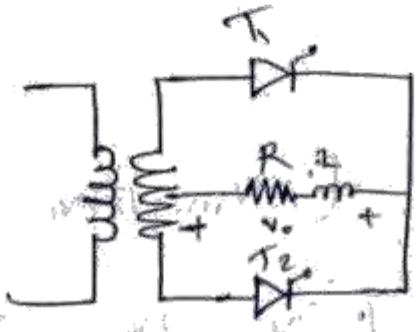
$VRF = \sqrt{FF^2 - 1} = \sqrt{1.879^2 - 1} = 1.5$

$TUF = \frac{V_o I_o}{V_s I_{srms}} = \frac{602.8}{230 \times 14.54} = 0.17$

$I_s = I_{orms}$

$PIV = V_m = \sqrt{2} \times V_m = 325$

(10) A 1-ϕ FULL Converter connected to 230 V, 50Hz source is leading a load are equal to 10Ω in series with a large inductor that makes the load current ripple for a firing angle of 45°, Calculate the i/p and o/p performance parameters of this Converter.



$V_o = \frac{2V_m}{\pi} \cos\alpha = \frac{2 \times \sqrt{2} \times 230}{\pi} \cos(45°) = 146.42\,V$

$I_o = \frac{V_o}{R} = \frac{146.42}{10} = 14.64\,A$

$V_{oRms} = \frac{V_m}{\sqrt{\pi}} \left[[\pi] + \frac{1}{2} \sin 2(\pi + \alpha) \right]^{1/2}$

$= \frac{230 \times \sqrt{2}}{\sqrt{\pi}} \left[[\pi] + \frac{1}{2} \sin 2(\pi + \pi/4) \right]^{1/2}$

$V_{oRms} =$

$I_{oRms} = \frac{V_{oRms}}{R} = 14.$

$$\eta = \frac{P_{dc}}{P_{a.c}} = \frac{V_o I_o}{V_{o\,rms} I_{o\,rms}} =$$

$$FF = \frac{V_{o\,Rms}}{V_o} = \quad 1.57$$

$$VRV = \sqrt{FF^2 - 1} = \sqrt{1.57^2 - 1} = 1.21$$

$$TUF = \frac{V_o I_o}{V_s I_s} = \frac{116.42 \times 14.64}{230 \times}$$

CRF (Current ripple factor) = 0

$$I_o = \frac{2\sqrt{2} \cdot I_o}{\pi} = 13.18$$

$\theta_1 = -\alpha, = -45°$

Displacement factor = $\cos\alpha = 0.707$

Total input current

$I_s = I_o = 14.64$ A

Active power (P) = $V_o I_o$

$P = V_s I_s \cos\phi$

$= V_s \left(\frac{2\sqrt{2} I_o}{\pi}\right) \cos\alpha$ $\quad \left(\because V_m = \sqrt{2} \times V_s\right.$

$= \frac{2V_m}{\pi} I_o \cos\alpha$ $\quad \left(\because V_o = \frac{2V_m}{\pi} \cos\alpha\right)$

$= V_o I_o \quad = 2143.7$ W

Reactive power = $\frac{2V_m}{\pi} I_o \sin\alpha$

$Q = V_s I_s \sin\alpha$

$Q = V_s \left(\frac{2\sqrt{2} I_o}{\pi}\right) \sin\alpha$

$= V_s \frac{2V_m}{\pi} I_o \sin\alpha = 4910.42$ W.

$= V_o I_o \sin\alpha$