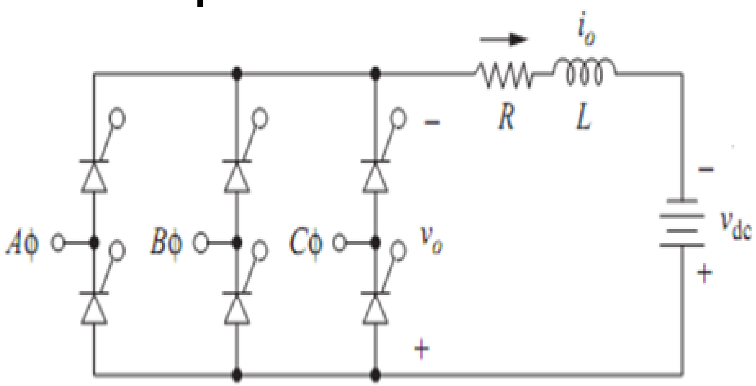
6 pulse converter with RLE Load

- Numerical problem => Inverter operation
- 6 pulse converter supplied from 400 V 3ϕ 50 Hz
- RLE load => R=10 Ω and
- L is very large & E= 450 V
- $\alpha = 120^0$ determine
- i) converter O/P voltage
- & DC current supplied by the battery
- ii) Power dissipated in R load
- iii) Source current and supply pf
- iv) active power provided by the battery
- V) Reactive power supplied from the source



Numerical problem: RLE load

$$V_{dc(av)} = \frac{3V_{ml}}{\pi}\cos\alpha = \frac{3\times\sqrt{2}\times 400}{\pi}\cos 120$$

$$\therefore V_{dc(av)} = -270.09\ V = -270.09V$$

$$I_{dc} = \frac{E - V_{dc(av)}}{R} = \frac{450-270.09}{10} = 17.99A$$

Power dissipated in R load $= I_{dc}^2 \cdot R$

$$= (17.99)^2 \times 10 = 3236.76\ W$$

source current $I_s = \sqrt{2/3} \cdot I_{dc} = \sqrt{2/3} \times 17.99$

$$= 14.688\ A$$

Numerical problem: RLE load

Supply pf $= \frac{3}{\pi}\cos\alpha = \frac{3}{\pi}\cos(120) = 0.477$ log

Active power provided by Battery

$$= E \times I_{dc} = 450 \times 17.99$$

$$= 8095.5\ W$$

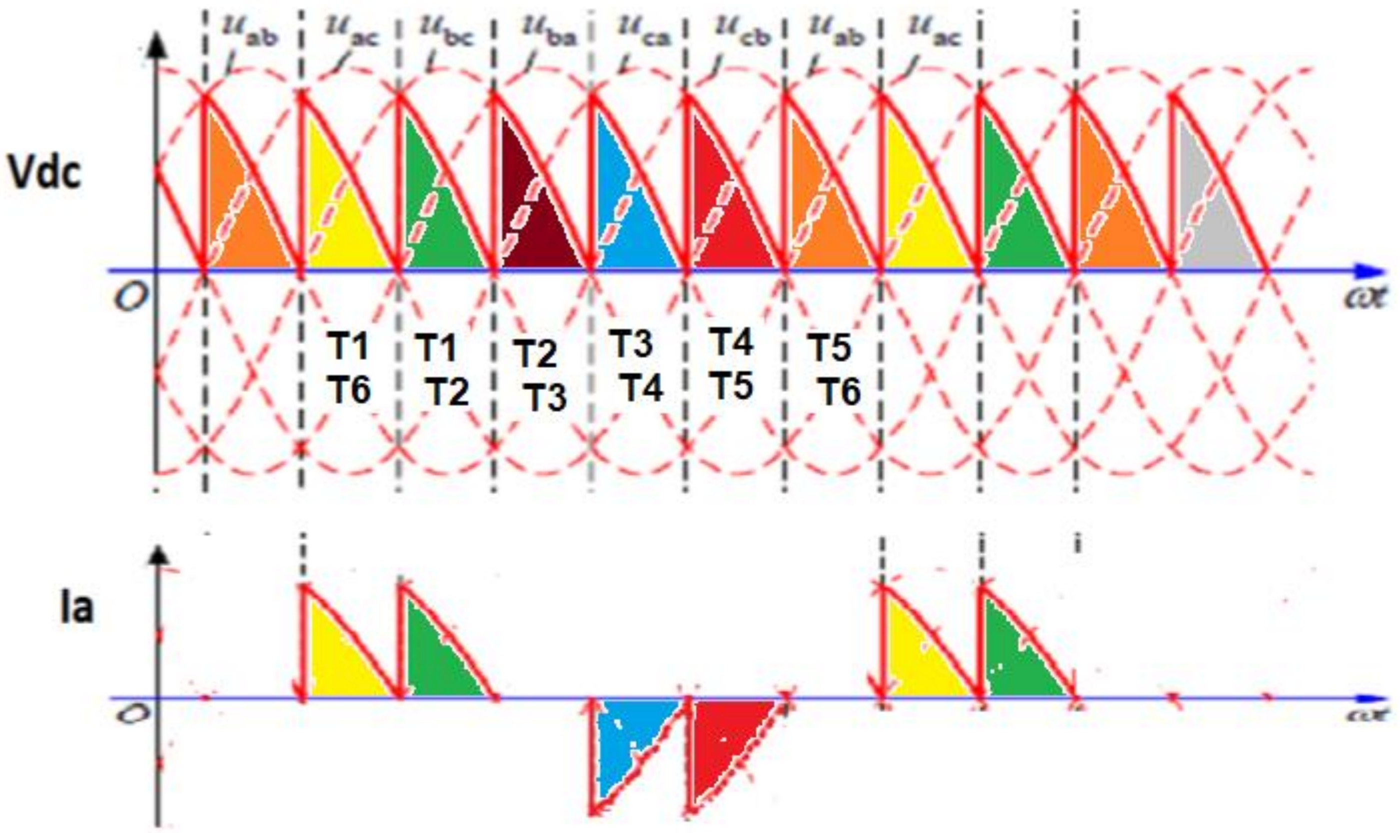
$\therefore$ Reactive power $= \sqrt{3} \cdot V_L \cdot I_L \sin\phi$

$$= \sqrt{3} \times 400 \times 14.688 \times \sin(61.51)$$

$$= 8943.81\ VAR$$

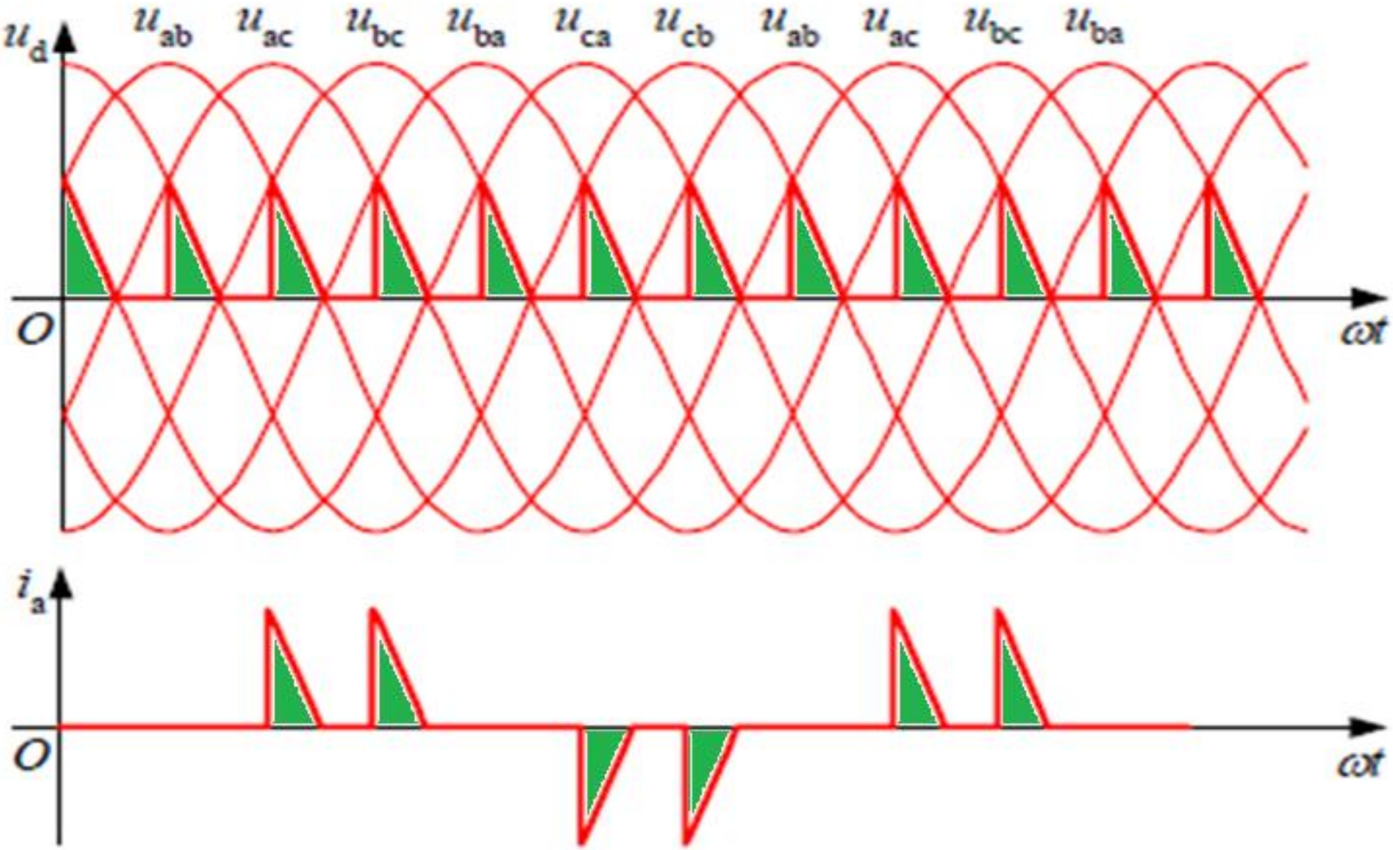
6 pulse converter with R Load

- continuous conduction => $0^0 < \alpha < 60^0$
- discontinuous conduction => $60^0 < \alpha < 120^0$
- Firing angle : $\alpha = 60^0$

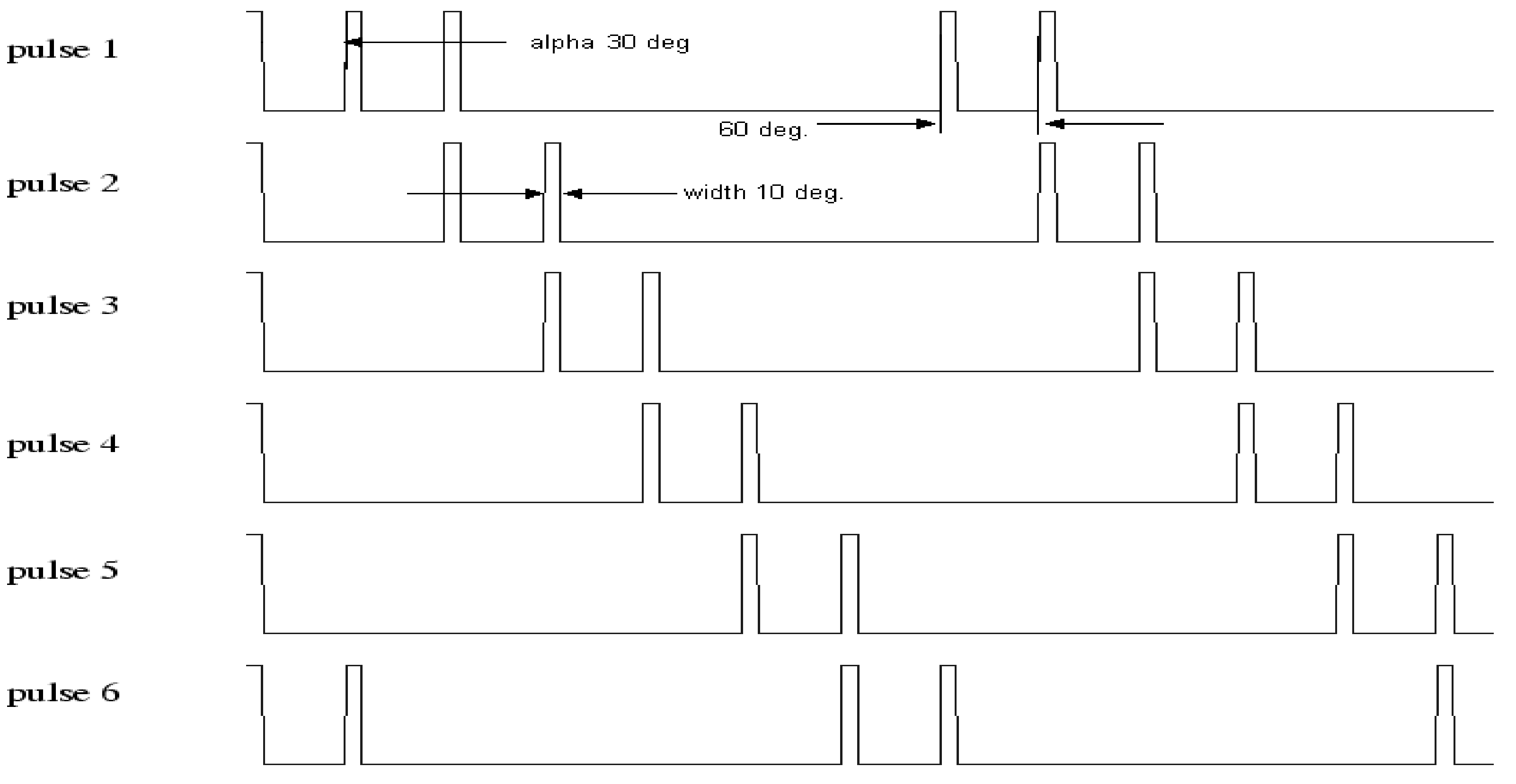


6 pulse converter with R Load

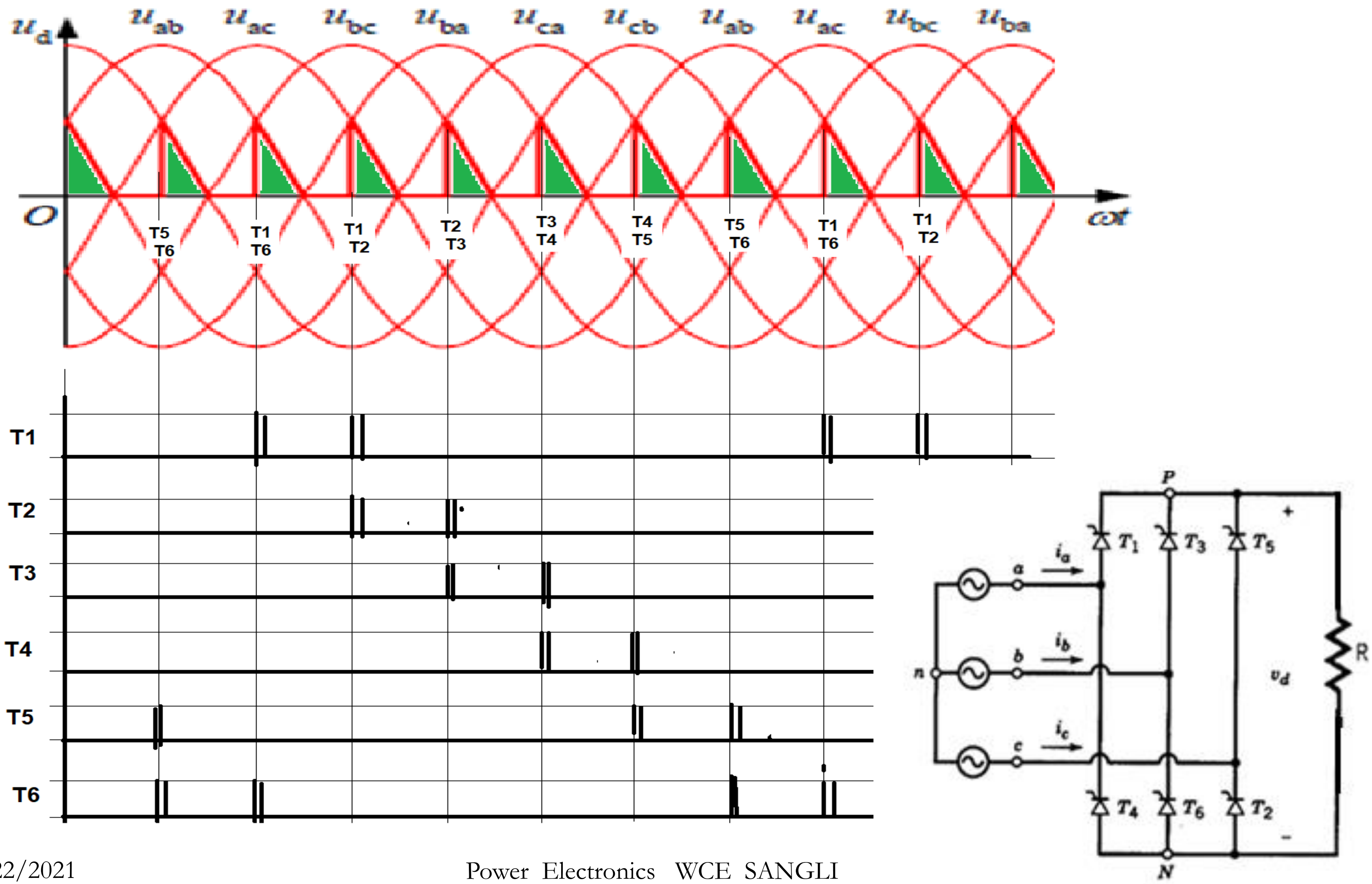
- Firing angle : $\alpha = 90^0$



Gating signal for 6 pulse converter

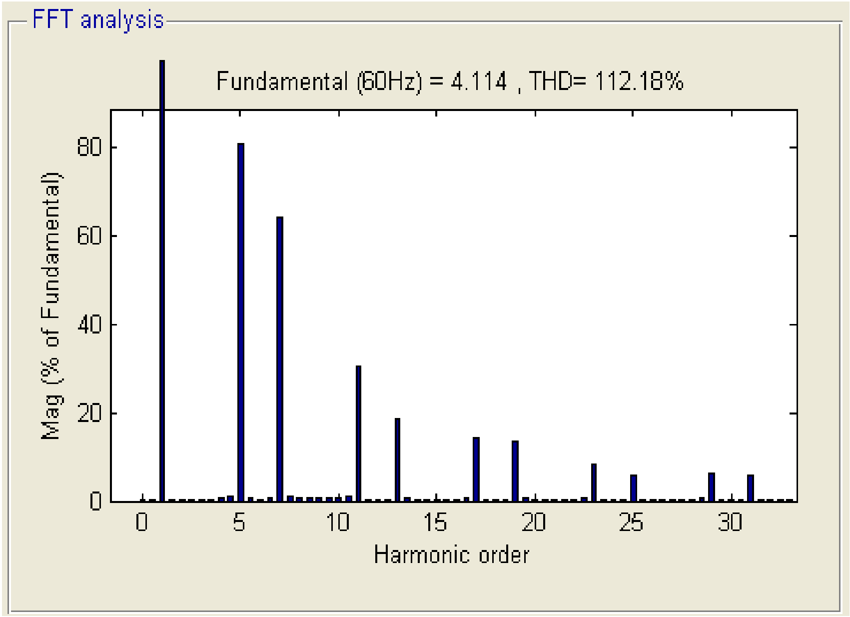


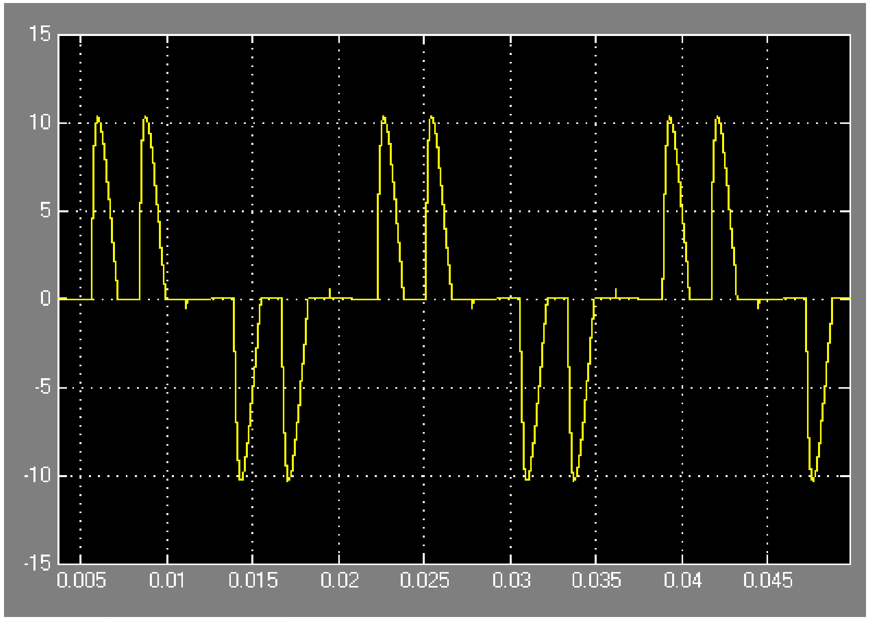
Gate trigger signal – 6 pulse converter



6 pulse converter with R Load

Firing angle = 90 degree





$$I_h = \sqrt{I_5^{\ 2} + I_7^{\ 2} + I_{11}^{\ 2} + I_{13}^{\ 2} + \cdots}$$
$$= \sqrt{\sum_{n=5,7,\ldots} I_n^{\ 2}}$$

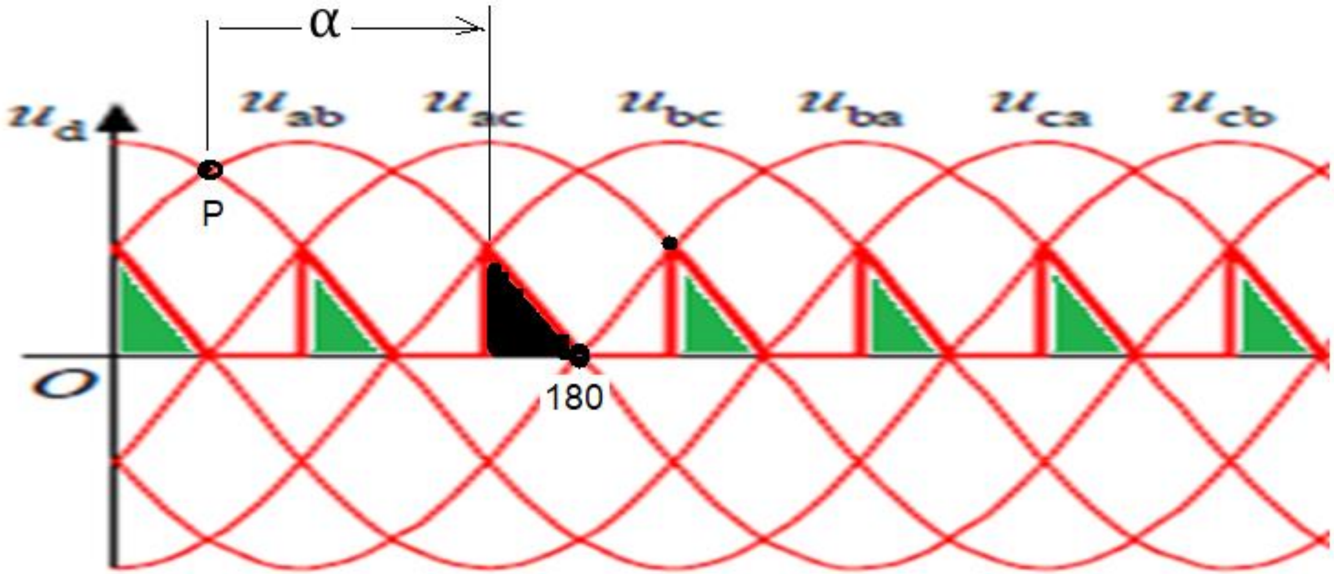
Range of α => 0 to 120^0

Continuous conduction => $\alpha < 60^0$

discontinuous conduction => $\alpha > 60^0$

6 pulse converter with R Load

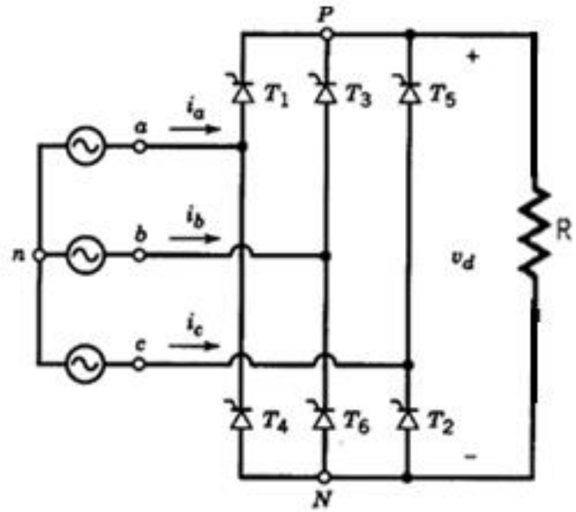
- DC O/P Voltage for R load ($60^0 < \alpha < 120^0$

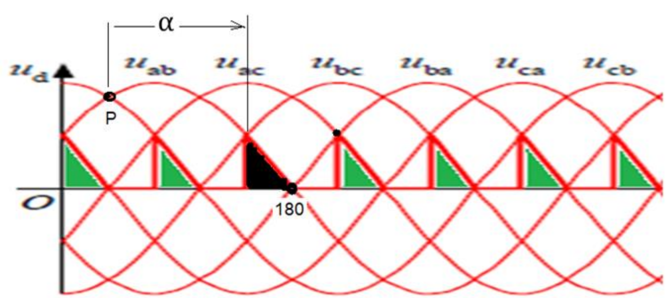


- Vdc(av) $=\frac{6}{2\pi}\int_{60+\alpha}^{180} Vml \sin\theta \; d\theta$
- Vdc(av) $=\frac{3}{\pi}\, Vml\,[1+\cos(60+\alpha)]$

6 pulse converter with R Load

- Numerical problem
- 6 pulse converter supplied from 400 V 3ϕ 50 Hz
- R load => R=10 Ω and
- $\alpha = 70^0$ determine
- i) converter O/P voltage Vdc (rms)
- ii) Power dissipated in R load
- iii) Vdc (av)
- iv) % ripple in O/P voltage





Numerical Problem: 6 pulse converter

$$V_{dc(rms)} = \left[\frac{6}{2\pi}\int_{130}^{180} V_{ml}^2 \cdot \sin^2\theta \cdot d\theta\right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{6\,V_{ml}^2}{2\pi}\int_{130}^{180} \sin^2\theta \cdot d\theta\right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3\,V_{ml}^2}{\pi}\int_{130}^{180} \left(\frac{1-\cos 2\theta}{2}\right) \cdot d\theta\right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3\,V_{ml}^2}{2\pi}\int_{130}^{180} d\theta - \int_{130}^{180} \cos 2\theta \cdot d\theta\right]^{1/2}$$

Numerical Problem: 6 pulse converter

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2\pi} \int_{130}^{180} d\theta - \int_{130}^{180} \cos 2\theta \cdot d\theta \right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2\pi} \left\{ \left(\theta \Big|_{130}^{180} \right) - \frac{1}{2} \sin 2\theta \Big|_{130}^{180} \right\} \right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2\pi} \left\{ \left(\pi - \frac{130}{180}\pi \right) + \frac{1}{2} \sin 260 \right\} \right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3 \times (\sqrt{2} \times 400)^2}{2\pi} \left\{ 0.872 + 0.492 \right\} \right]^{1/2}$$

$$V_{dc(rm)} = 240.95\,V$$

Numerical Problem: 6 pulse converter

Power dissipated in R load $= \frac{V_{dc(rms)}^2}{R}$

$$= \frac{240.95^2}{10} = 5805.69 \text{ W}$$

$$V_{dc(av)} = \frac{6}{2\pi}\int_{130}^{180} V_{ml} \sin\theta \cdot d\theta$$

$$V_{dc(av)} = \frac{3V_{ml}}{\pi}\left[-\cos\theta\right]\Big|_{130}^{180}$$

$$V_{dc(av)} = \frac{3V_{ml}}{\pi}\left[-\cos 180 + \cos 130\right]$$

$$= \frac{3 \times \sqrt{2} \times 400}{\pi}\left[-(-1) + (-0.6427)\right.$$

Numerical Problem: 6 pulse converter

$$V_{dc}(av) = \frac{3 \times \sqrt{2} \times 400}{\pi}(1 - 0.6427)$$

$$V_{dc}(av) = 193\,V$$

$$FF = \frac{V_{dc}(rms)}{V_{dc}(av)} = \frac{240.95}{193.0} = \frac{240.95}{193.0}$$

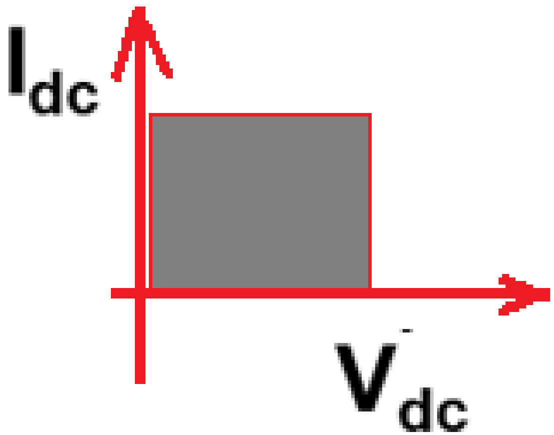
$$FF = 1.248$$

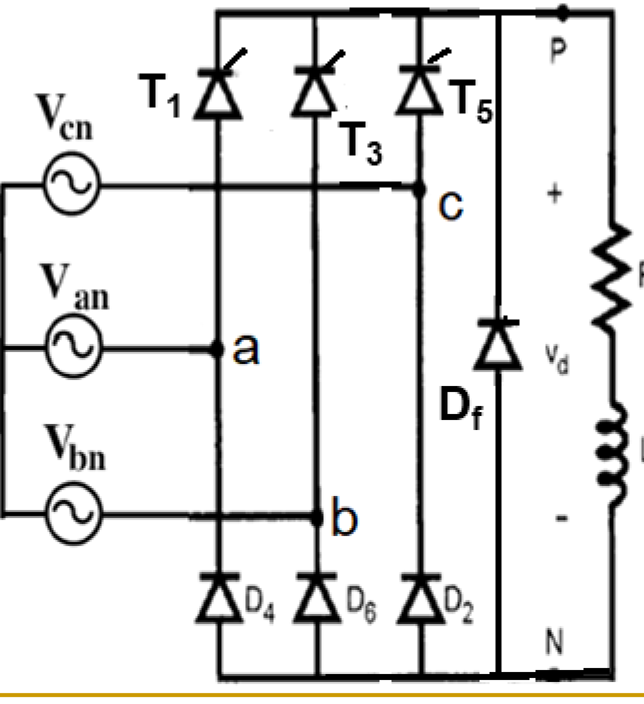
$$\%\,Ripple = \sqrt{1.248^2 - 1} \times 100$$

$$= 74.73\%$$

3ϕ full wave half controlled converter

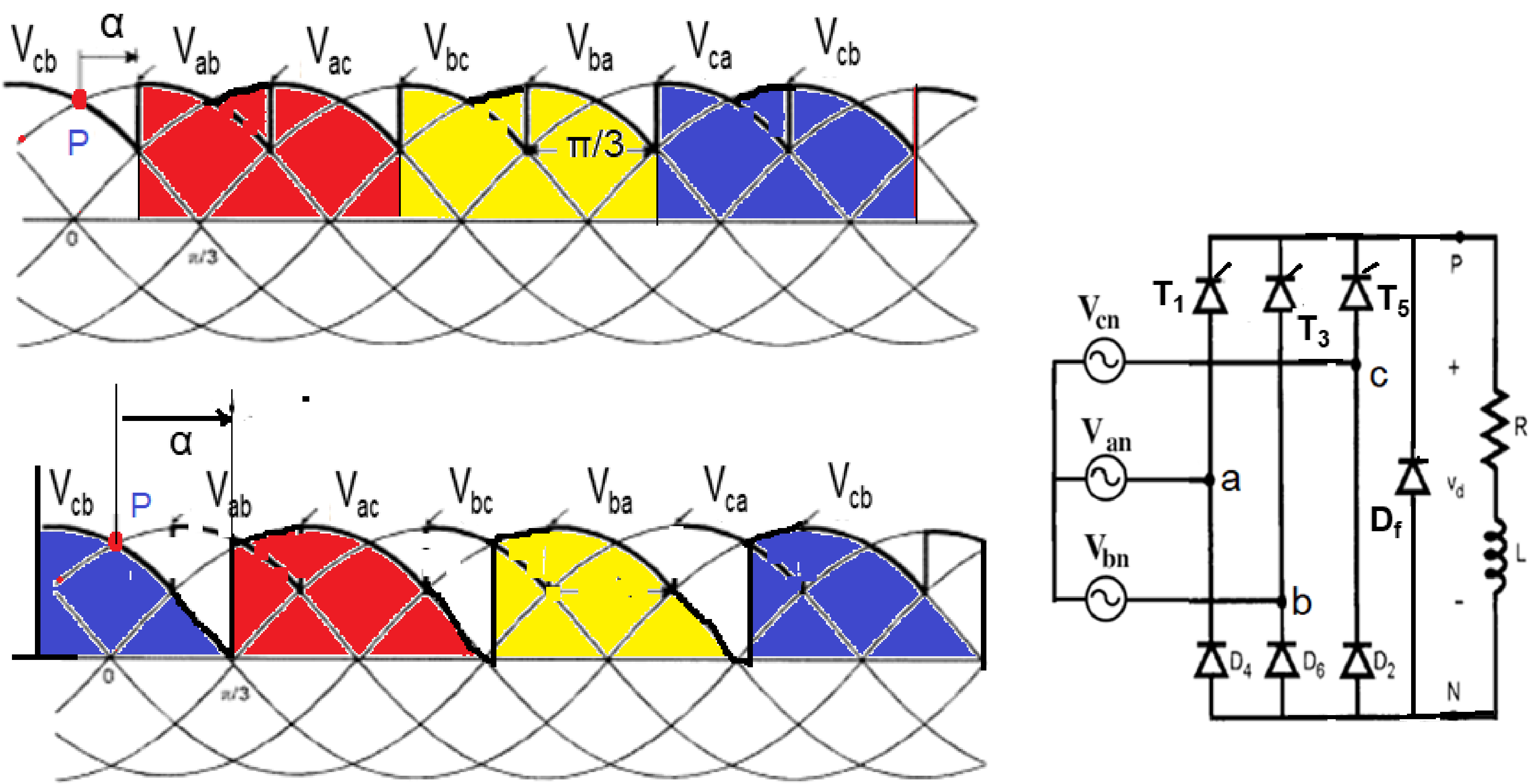
- Single quadrant converter
- Range of α => 0^0 to 180^0
- 3 pulse half controlled converter





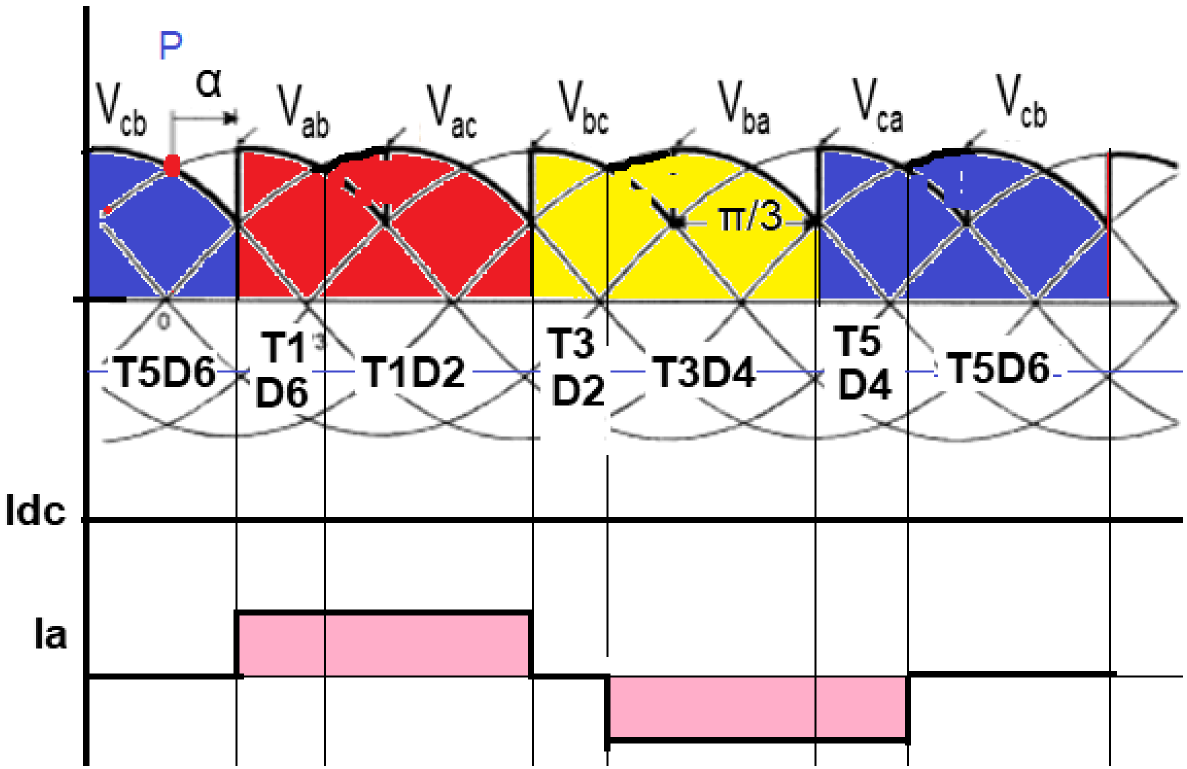
3ϕ full wave half controlled converter

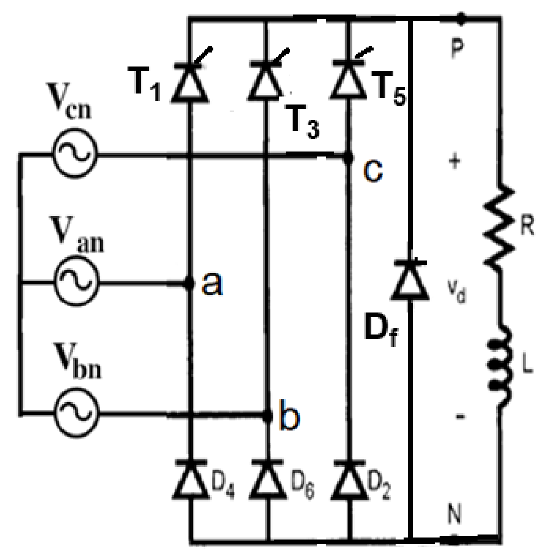
- Waveform at α = 30⁰ and α = 60⁰



3ϕ full wave half controlled converter

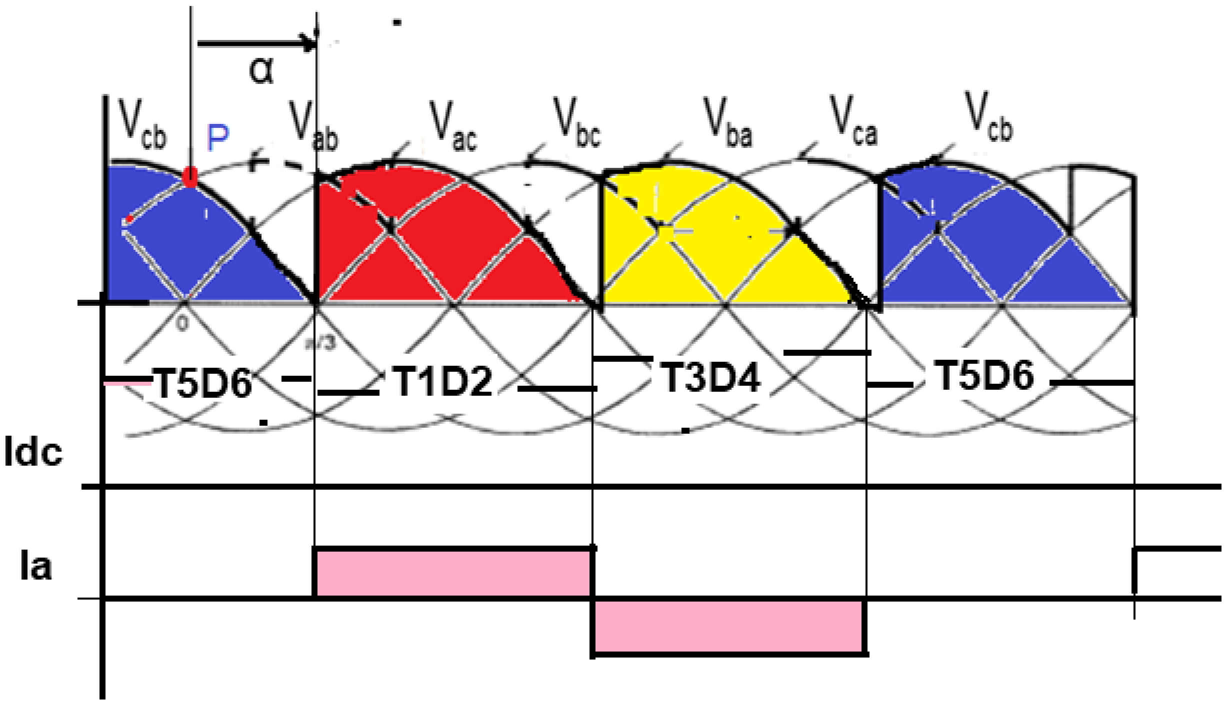
- Firing angle α = 30^0





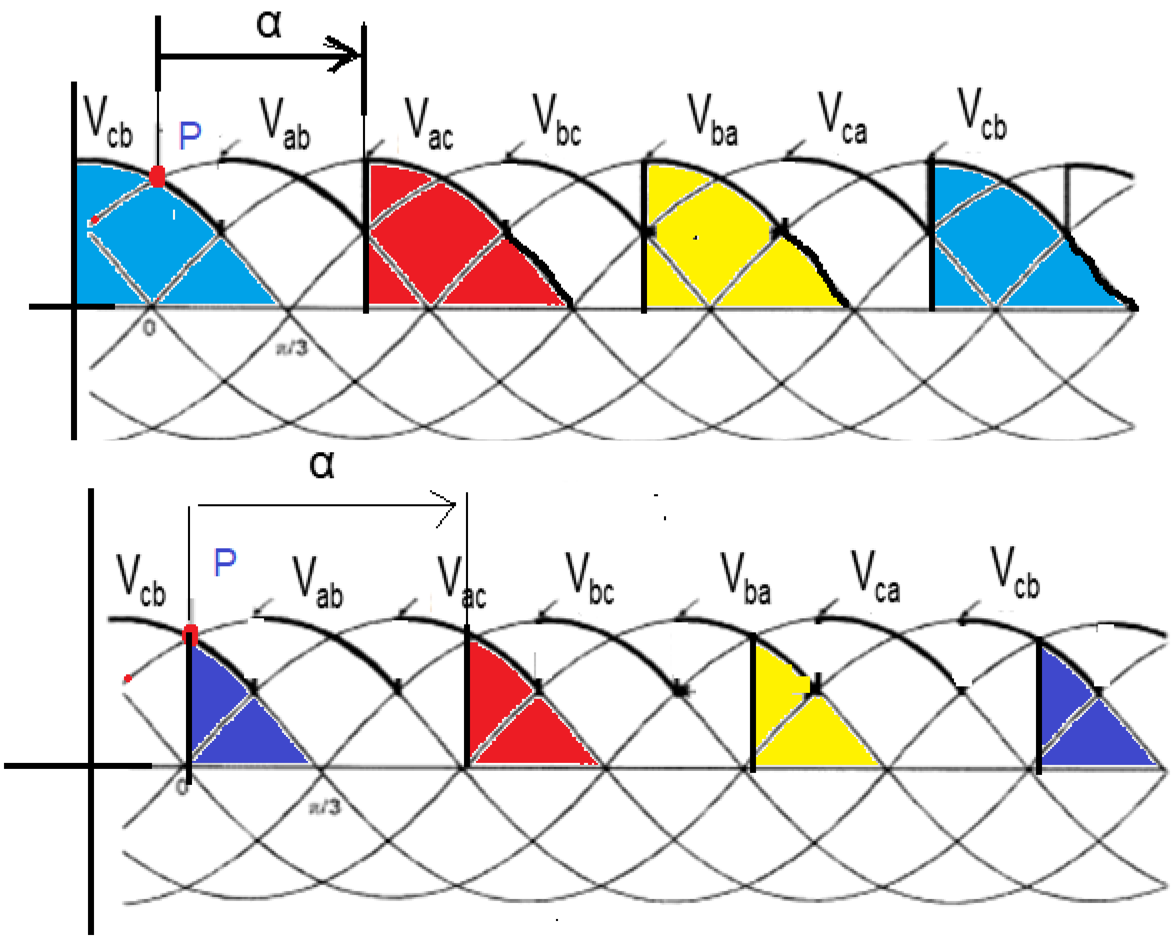
3ϕ full wave half controlled converter

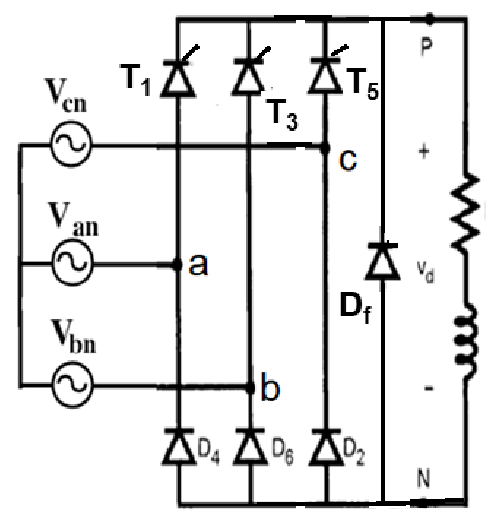
- Vdc waveform $\alpha = 60^0$



3ϕ full wave half controlled converter

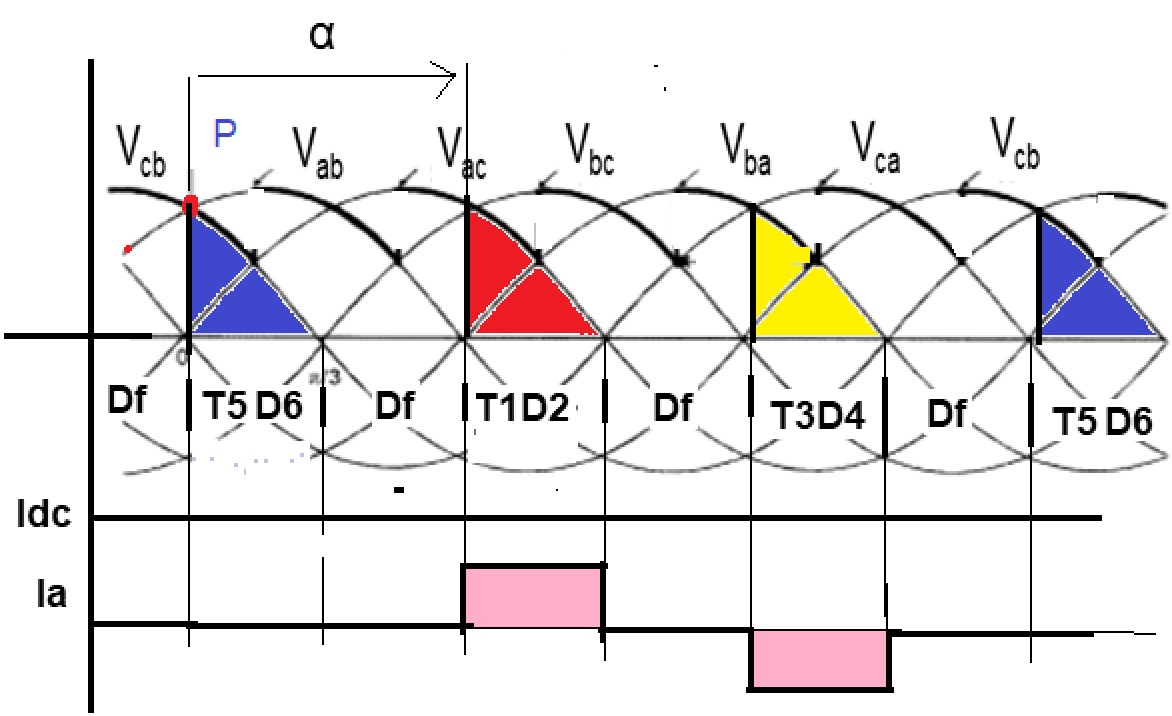
- Waveform at $\alpha = 90^0$ $\alpha = 120^0$

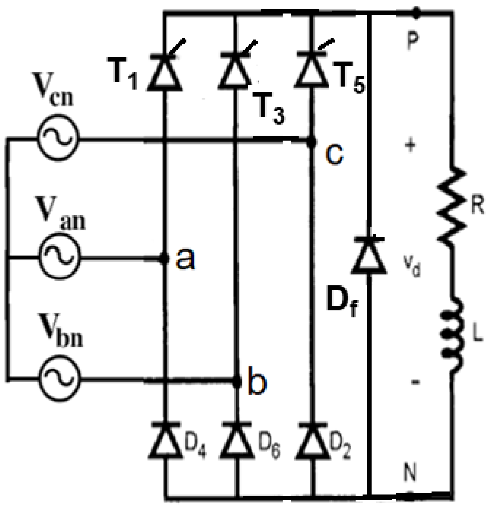




3ϕ full wave half controlled converter

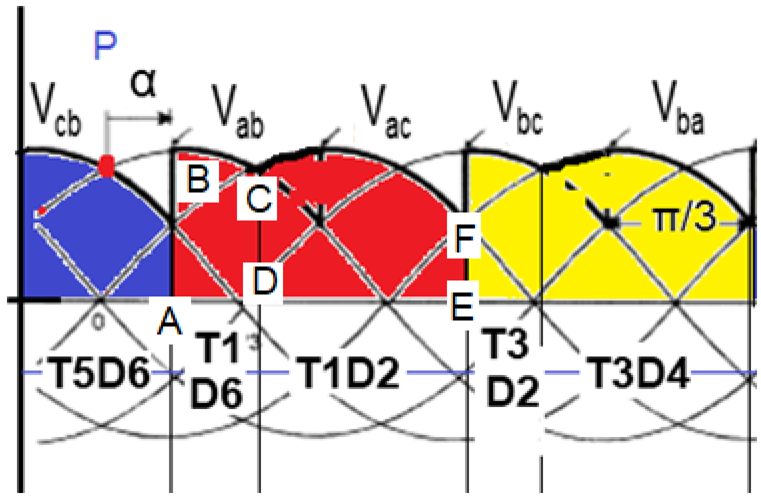
- Waveform at $\alpha = 120^0$





3ϕ full wave half controlled converter

- o/p voltage is same for R and RL load



- Vdc(av)= 3[area (ABCD) +area(CDEF)]/ 2 π
- Vdc (av)= $\frac{3}{2\pi}[\int_{60+\alpha}^{120} Vmlsin\theta \, d\theta + \int_{60}^{120+\alpha} Vmlsin\theta \, d\theta]$
- Vdc (av)= $\frac{3\,Vml}{2\pi}[\,1+\cos\alpha]$

3ϕ full wave half controlled converter

$$A = \int_{60+\alpha}^{120} V_{ml} \sin\theta . d\theta = V_{ml}(-\cos\theta)\Big|_{60+\alpha}^{120}$$

$$\therefore A = V_{ml}\left[-\cos 120 + \cos(60+\alpha)\right]$$

$$A = V_{ml}\left[0.5 + \cos 60 \cos\alpha - \sin 60 \sin\alpha\right]$$

$$A = V_{ml}\left[0.5 + 0.5\cos\alpha - 0.866\sin\alpha\right]$$

$$B = \int_{60}^{120+\alpha} V_{ml} \sin\theta . d\theta = V_{ml}(-\cos\theta)\Big|_{60}^{120+\alpha}$$

3ϕ full wave half controlled converter

$$B = V_{ml}\left[-\cos(120+\alpha)+\cos 60\right]$$

$$B = V_{ml}\left[\cos 60 - \left[\cos 120 \cos\alpha - \sin 120 \sin\alpha\right]\right]$$

$$B = V_{ml}\left[0.5 + 0.5\cos\alpha + 0.866\sin\alpha\right]$$

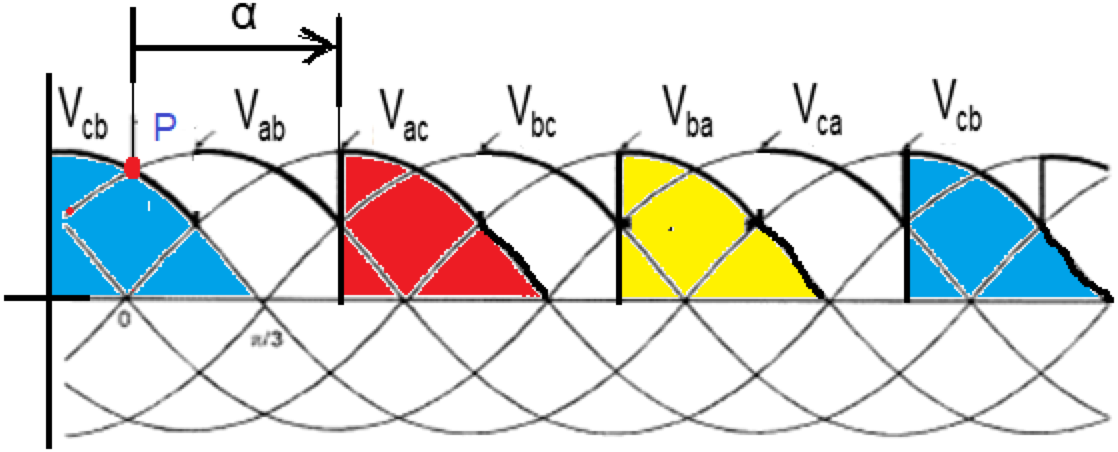
$$V_{dc\,(av)} = \frac{3}{2\pi}\left[A+B\right]$$

$$= \frac{3V_{ml}}{2\pi}\left[0.5 + 0.5\cos\alpha - 0.866\sin\alpha + 0.5 + 0.5\cos\alpha + 0.866\sin\alpha\right]$$

$$= \frac{3V_{ml}}{2\pi}\left(1+\cos\alpha\right)$$

3ϕ full wave half controlled converter

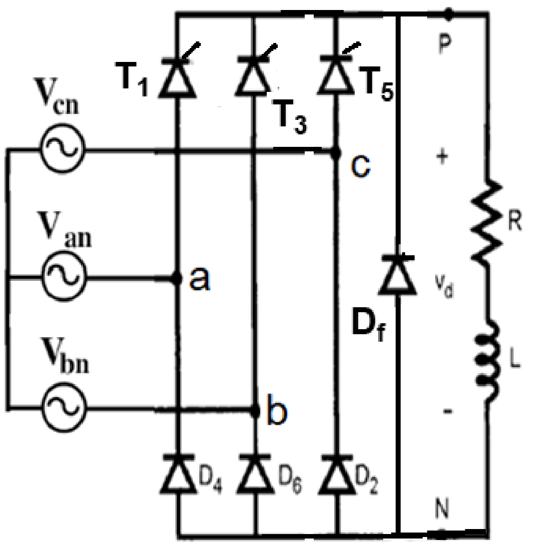
- o/p voltage is same for R and RL load

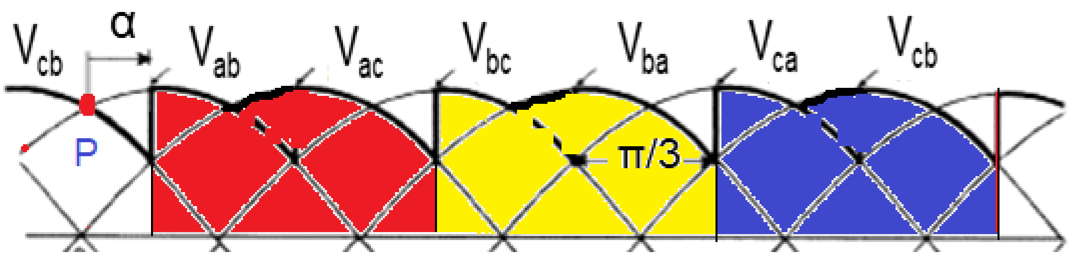


- Vdc (av)= $\frac{3}{2\pi}[\int_{\alpha}^{180} Vml \sin\theta \, d\theta$
- Vdc (av)= $\frac{3\,Vml}{2\pi}[\,1+\cos\alpha]$

3ϕ full wave half controlled converter

- Numerical Problem
- 3ϕ full wave half controlled supplied => 400 V 3ϕ 50 Hz
- RL load => R=25 Ω and L is very large
- $\alpha = 30^0$ determine
- i) dc O/P voltage & DC current
- ii) Power dissipated in R load
- iii) Source current and supply pf
- iv) Active and reactive power supplied from the source





3ϕ full wave half controlled converter

$$V_{dc(av)} = \frac{3V_{ml}}{2\pi}(1+\cos\alpha)$$

$$V_{dc(av)} \quad \frac{3\times\sqrt{2}\times 400}{2\pi}(1+\cos 30) = \quad 504V$$

$$I_{dc} = \frac{V_{dc(av)}}{R} = \frac{504}{25} = 20.16A$$

$$P_{dc} = V_{dc(av)}\cdot I_{dc} = I_{dc}^2\cdot R = 20.16^2\times 25 = 10160.64W$$

$$I_{ac} = \sqrt{2/3}\cdot I_{dc} = 16.46A$$

AC Power = DC Power

$$\sqrt{3}\,V_L I_L \cos\phi = V_{dc}\cdot I_{dc}$$

$$\cos\phi = \frac{V_{dc}\cdot I_{dc}}{\sqrt{3}\times 400\times 16.46}$$

3ϕ full wave half controlled converter

$$\cos\phi = \frac{504 \times 20.16}{\sqrt{3} \times 400 \times 16.46}$$

$$\cos\phi = 0.891$$

$$pf = 0.891 \qquad \phi = 27$$

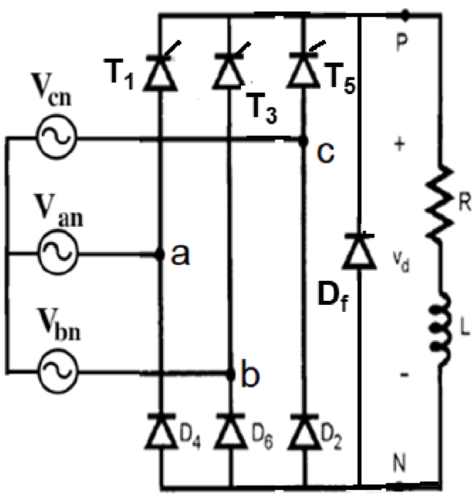
Active Power = 10160.64 W

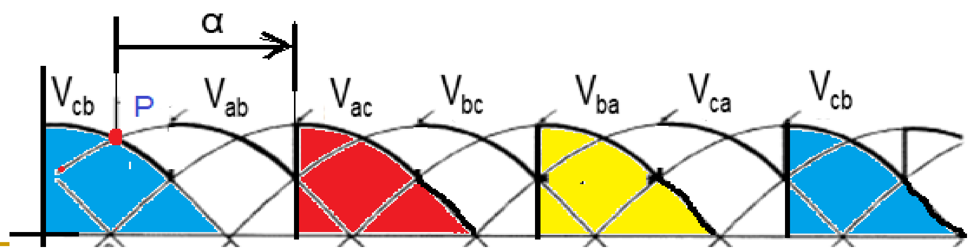
Reactive Power = $\sqrt{3}\, V_L I_L \sin 27$

Reactive Power = 5177.22 VAR

3ϕ full wave half controlled converter

- Numerical Problem
- 3ϕ full wave half controlled supplied => 400 V 3ϕ 50 Hz
- RL load => R=10 Ω and L is very large
- $\alpha = 90^0$ determine
- i) dc O/P voltage & DC current
- ii) Power dissipated in R load
- iii) Source current and supply pf
- iv) Active and reactive power supplied from the source





3ϕ full wave half controlled converter

$$V_{dc(av)} = \frac{3 V_{mL}}{2\pi}(1+\cos\alpha)$$

$$V_{dc(av)} = \frac{3\times\sqrt{2}\times 400}{2\pi}(1+\cos 90) = 270.09\,V$$

$$I_{dc} = \frac{V_{dc(av)}}{R} = \frac{270.09}{10} = 27.01\,A$$

Power dissipated in R load $= I_{dc}^2 \cdot R = V_{dc} \cdot I_{dc}$

$= 7294.86\,W$

RMS value of source current $= \sqrt{1/2} \cdot I_{dc}$

$= 19.09\,A$

Active power $= \sqrt{3}\, V_L \cdot I_L \cos\phi = V_{dc(av)} \cdot I_{dc}$

$= 7294.86\,W$

3ϕ full wave half controlled converter

RMS value of source current $= \sqrt{1/2} \cdot I_{dc}$

$= 19.09\ A$

Active power $= \sqrt{3}\, V_L \cdot I_L \cos\phi = V_{dc(av)} \cdot I_{dc}$

$= 7294.86\ W$

$$\cos\phi = \frac{V_{dc} \cdot I_{dc}}{\sqrt{3}\, V_L \cdot I_L} = \frac{7294.86}{\sqrt{3} \times 400 \times 19.09}$$

$\cos\phi = pf = 0.551 \qquad \phi = 56.56^\circ$

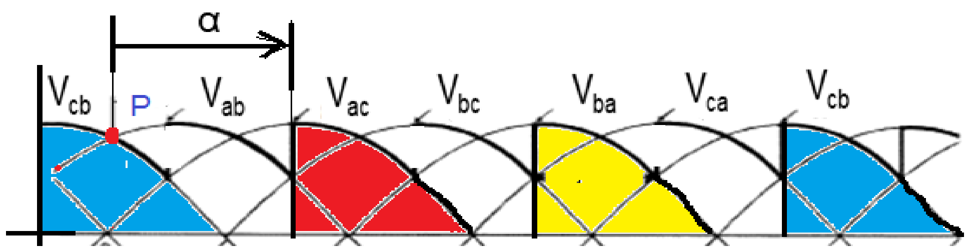
Reactive power $= \sqrt{3} \cdot V_L I_L \sin\phi$

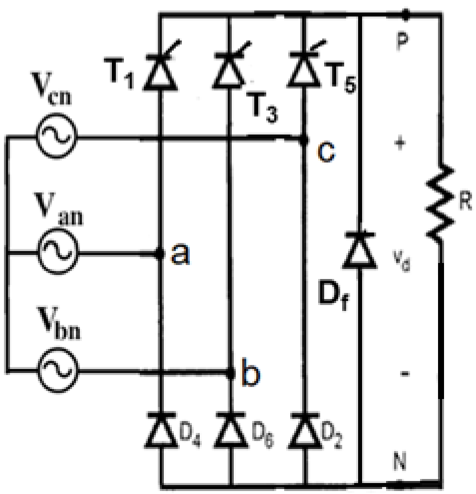
$= \sqrt{3} \times 400 \times 19.09 \times \sin 56.56$

$= 10,990.31\ VAR$

3ϕ full wave half controlled converter

- Numerical Problem
- 3ϕ full wave half controlled supplied => 400 V 3ϕ 50 Hz
- R load => R=10 Ω
- $\alpha = 90^0$ determine
- i) Vdc (av) and Vdc(rms)
- ii) Power dissipated in R load
- iii) % ripple in the output
- Iv) Avg current flowing through Df





3ϕ full wave half controlled converter

$$V_{dc(av)} = \frac{3V_{ml}}{2\pi}(1+\cos\alpha)$$

$$= \frac{3 \times \sqrt{2} \times 400}{2\pi}(1+\cos 90) = 270.09\ V$$

$$V_{dc(rms)} = \left[\frac{3}{2\pi}\int_{90}^{180} V_{ml}^2 \sin^2\theta \cdot d\theta\right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2\pi}\int_{90}^{180} \sin^2\theta \cdot d\theta\right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2\pi}\int_{90}^{180} \left(\frac{1-\cos 2\theta}{2}\right) \cdot d\theta\right]^{1/2}$$

3ϕ full wave half controlled converter

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2\pi} \int_{90} \left(\frac{1 - \cos 2\theta}{2} \right) \cdot d\theta \right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{2 \times 2\pi} \left\{ \int_{90}^{180} d\theta - \int_{90}^{180} \cos 2\theta \cdot d\theta \right\} \right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{4\pi} \left\{ \theta \Big|_{\pi/2}^{\pi} - \frac{1}{2} \sin 2\theta \Big|_{90}^{180} \right\} \right]^{1/2}$$

$$V_{dc(rms)} = \left[\frac{3V_{ml}^2}{4\pi} \left\{ \left(\pi - \pi/2 \right) - 1/2 \left(\sin 360 - \sin 180 \right) \right\} \right]^{1/2}$$

$$= \left[\frac{3V_{ml}^2}{4\pi} \times \frac{\pi}{2} \right]^{1/2} = \left[\frac{3V_{ml}^2}{8} \right]^{1/2}$$

$$= \left[\frac{3 \times (\sqrt{2} \times 400)^2}{8} \right]^{1/2} = 346.41\,V$$

3ϕ full wave half controlled converter

Power dissipated in R load = $V_{dc(rms)}^2 / R$

$$= \frac{346.41^2}{10} =$$

$$\text{Form Factor} = \frac{V_{d(rms)}}{V_{dc(av)}} = \frac{346.41}{270.09} = 1.2825$$

$$\%\ \text{Ripple} = \sqrt{FF^2 - 1} \times 100 = 80.298\%$$