<u>Review</u>

Each phase conducts for 240°(120° in each 1/2 a cycle)

⇒ At a time only two devices are ON.

⇒ One phase is open circuited.

It does not supply power.

⇒There are 6 pulses/cycle.

⇒ Hence the name Six Pulse Converter.

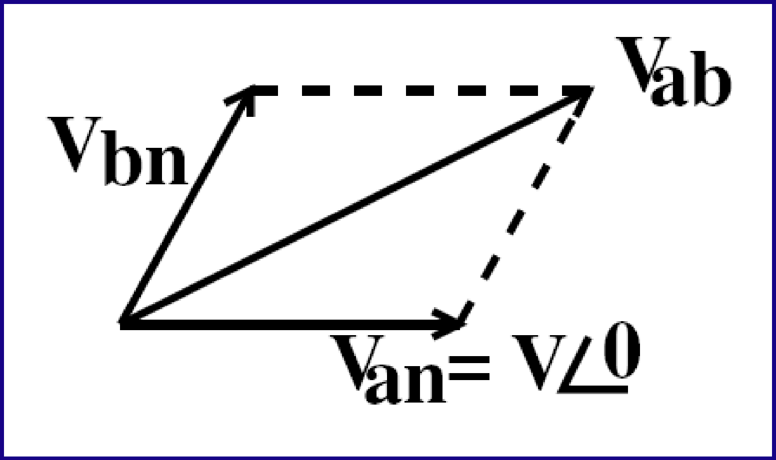
$\Rightarrow$ There are 6 pairs & each pair conducts for 60°.

$\Rightarrow$ At any given time 1 upper device & one lower device(not of the same leg) conduct.

$\Rightarrow$ Peak value of $V_0 = \sqrt{3}V_m = \sqrt{2}(\sqrt{3}V)$

Where V_m = peak of phase voltage

V = RMS Value of line-line voltage



$$\therefore \text{Avg. } V_0 = \frac{6}{2\pi}\int_{\frac{\pi}{6}+\alpha}^{\frac{\pi}{6}+\alpha+\frac{\pi}{3}} V_{ab}\,d(\omega t)$$

$$= \frac{6}{2\pi}\int_{\frac{\pi}{6}+\alpha}^{\frac{\pi}{6}+\alpha+\frac{\pi}{3}} \sqrt{3}V_m \sin(\omega t+30)\,d(\omega t)$$

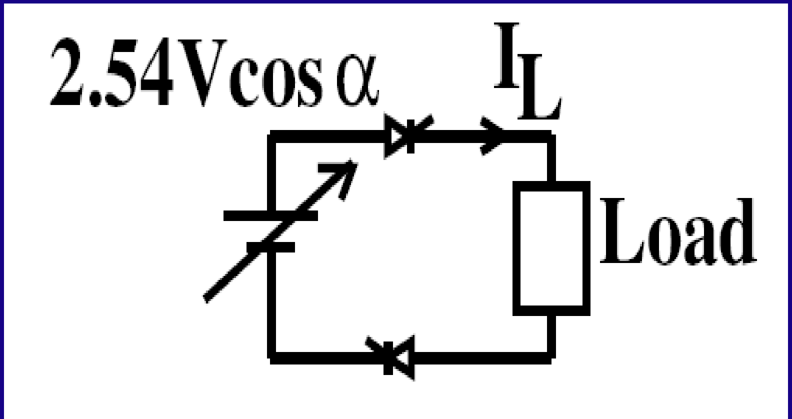
$$= \frac{3\sqrt{3}}{\pi} V_m \cos\alpha = 2.54\,V\,\text{Cos}\,\alpha$$

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

$\Rightarrow V_0$ = 2[o/p 'V' of 3-phase half wave controlled rectifier]

value of source current $= [\frac{1}{\pi} \times I_0 \times \frac{2\pi}{3}]^{\frac{1}{2}} = \sqrt{\frac{2}{3}} I_0$

$\therefore$ Equivalent circuit



α=30°

At $\omega t=60^{+}$ (w.r.t +ve zero crossing of phase A voltage). T_1 is Triggered.

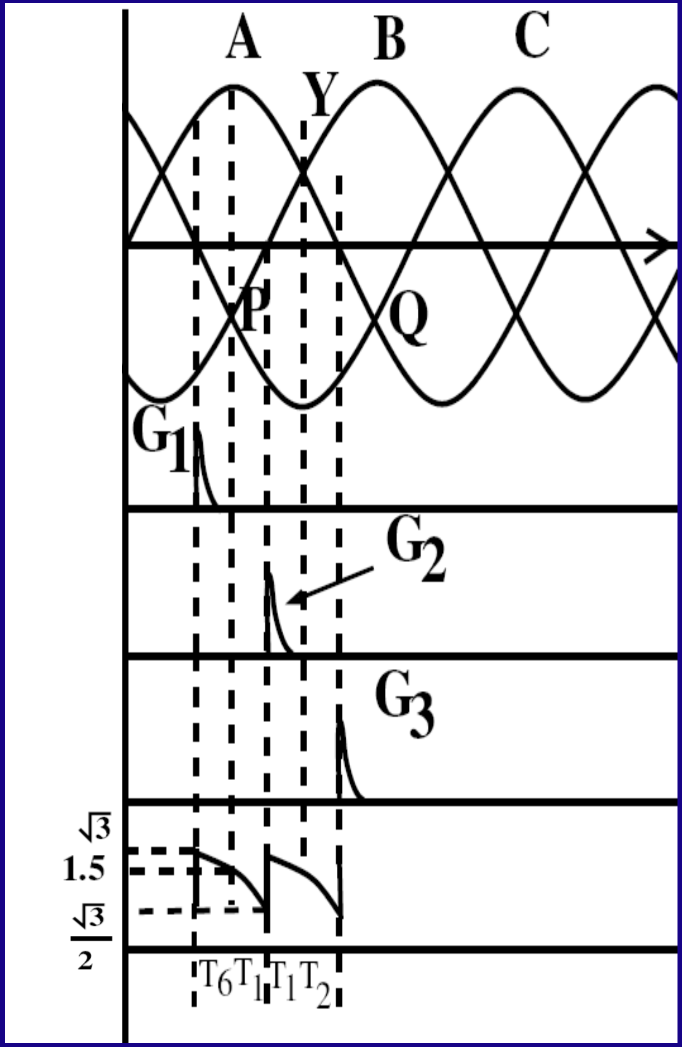
$\Rightarrow$ Prior to this T_5 was conducting, in the lower half T_6 is conducting.

At $\omega t=60^{+}$,

$V_0=V_{an}-V_{bn}$

$$V_{an}=\sin 60° = \frac{\sqrt{3}}{2}, V_{bn}=\sin 300° = \frac{-\sqrt{3}}{2}$$

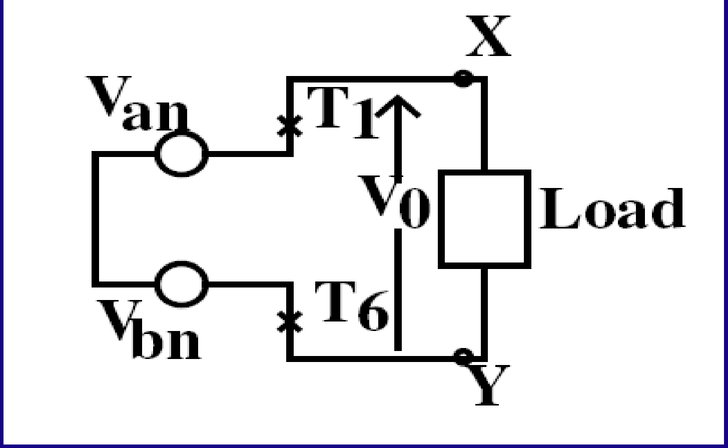
$$\therefore V_0=\sqrt{3}$$



At $\omega t = 60^-$, $V_0 = V_{cn} - V_{bn}$ ($\because T_6$ is conducting)

$V_{cn} = \text{Sin}\,180° = 0$, $V_{bn} = \text{Sin}\,300° = \frac{-\sqrt{3}}{2}$

$\therefore V_0 = \frac{\sqrt{3}}{2}$



$\therefore$ At $\omega t = 60^-$, $V_0 = \frac{\sqrt{3}}{2}$

$= 60^+$, $V_0 = \sqrt{3}$

At $\omega t = 90$, $V_{an} = 1$, $V_{bn} = \text{Sin}\,330° = \frac{-1}{2}$ $\therefore V_0 = \frac{3}{2} = 1.5$

$$\text{At } \omega t = 120^{-},\ V_{an} = \frac{\sqrt{3}}{2}, V_{bn} = 0\ \therefore V_0 = \frac{\sqrt{3}}{2}$$

$$\text{At } \omega t = 120^{+}, T_2 \text{ is Triggered.} \therefore V_0 = V_{an} - V_{cn}$$

$$V_{cn} = \text{Sin}\,240° = \frac{-\sqrt{3}}{2}, V_{an} = \frac{\sqrt{3}}{2}\ \therefore V_0 = \sqrt{3}$$

<u>Observation</u> :

$$\text{Peak value of } V_0 = \sqrt{3}V_m = \text{Peak of line-line voltage}$$

α=60°

Just prior to triggering T_1,
T_5 was conducting & from lower half T_6 is conducting.

$V_0 = V_{cn} - V_{bn}$

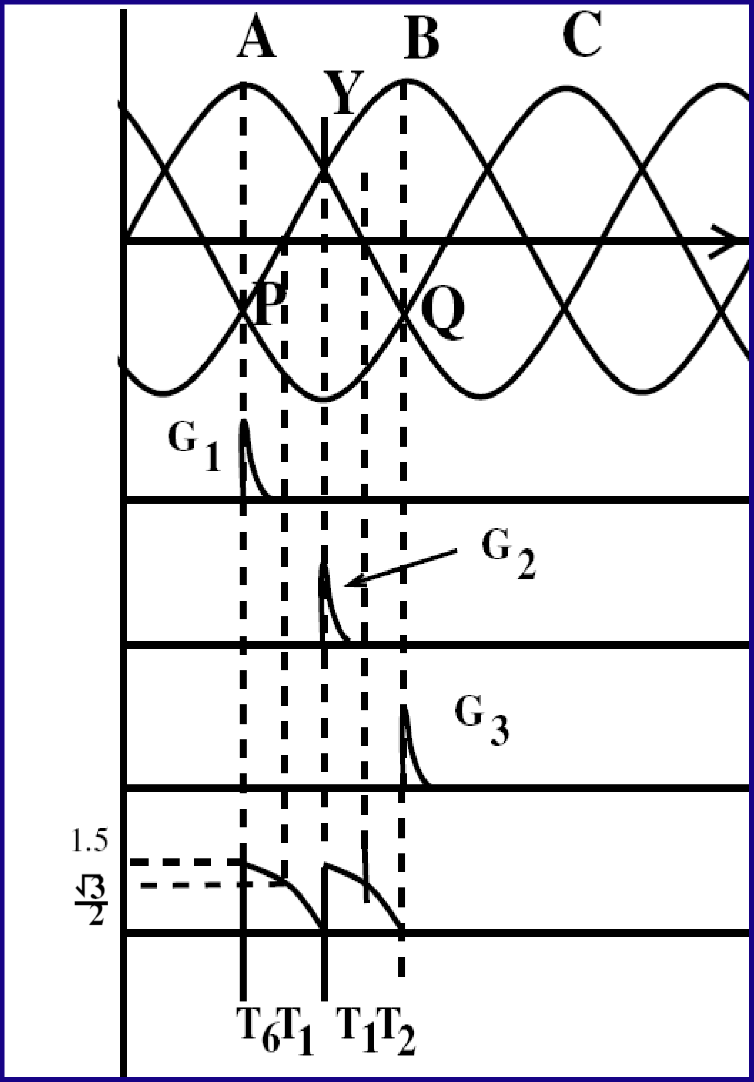
$V_{cn} = \text{Sin}\,210° = \frac{-1}{2}$,

$V_{bn} = \text{Sin}\,330° = \frac{-1}{2} \quad \therefore V_0 = 0$

When T_1 is triggered α=60°

$V_0 = V_{an} - V_{bn}$, $V_{an} = 1$,

$V_{bn} = \text{Sin}\,330° = \frac{-1}{2} \quad \therefore V_0 = 1.5$



$$\text{At } \omega t = 120, V_{an} = \text{Sin}\,120° = \frac{\sqrt{3}}{2}, V_{bn} = \text{Sin}\,360° = 0, \therefore V_0 = \frac{\sqrt{3}}{2}$$

$$\text{At } \omega t = 150^-, V_{an} = \frac{1}{2}, V_{bn} = \text{Sin}\,30° = \frac{1}{2} \therefore V_0 = 0$$

$$\text{At } \omega t = 150^+, T_2 \text{ is triggered}, V_0 = V_{an} - V_{cn}$$

$$V_{an} = \frac{1}{2}, V_{cn} = \text{Sin}\,270° = -1 \therefore V_0 = 1.5$$

<u>Observation</u> :

Peak value of $V_0 = 1.5$

Min value of $V_0 = 0$

$\alpha = 90° \left(\omega t = 120\right)$

When T_1 is triggered

$V_{an} \ \alpha \ \ Sin120 = \sqrt{3}/2$

T_6 is conducting in the lower half

$V_{bn} \ \alpha \ \ Sin360 = 0$

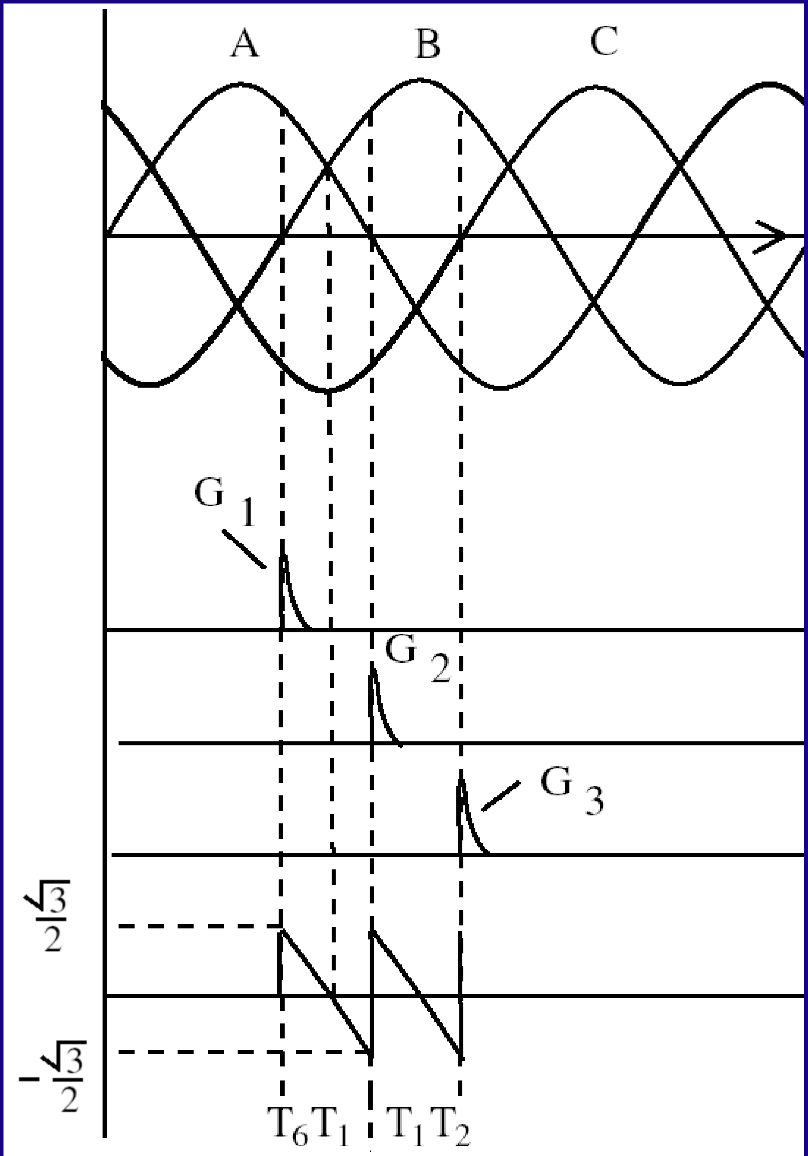
$\therefore \ V_0 = \sqrt{3}/2$

at $\omega t = 150$

$V_{an} \ \alpha \ \ Sin150 = 1/2$

$V_{bn} \ \alpha \ \ Sin30 = 1/2$

$\therefore \ V_0 = V_{an} - V_{bn} = 0$



$\text{at } \omega t = 180^-$

$V_{an} = 0$

$V_{bn} \ \alpha \ \text{Sin}60^- = \sqrt{3}/2$

$\therefore V_0 = -\sqrt{3}/2$

$\text{at } \omega t = 180^+ \ T_2 \text{ is triggered}$

$V_0 = V_{an} - V_{cn}$

$V_{cn} \ \alpha \ \text{Sin}300 = -\sqrt{3}/2$

$\therefore V_0 = \sqrt{3}/2$

$\therefore \text{Av. } V_0 = 0 \ (\text{Provided } i_L \text{ is continuous})$

$\alpha = 120° \ (\omega t = 150)$

When T_1 is triggered

$V_{an} \ \alpha \ \text{Sin}150 = 1/2$

T_6 is conducting in the lower half

$V_{bn} \ \alpha \ \text{Sin}30 = 1/2$

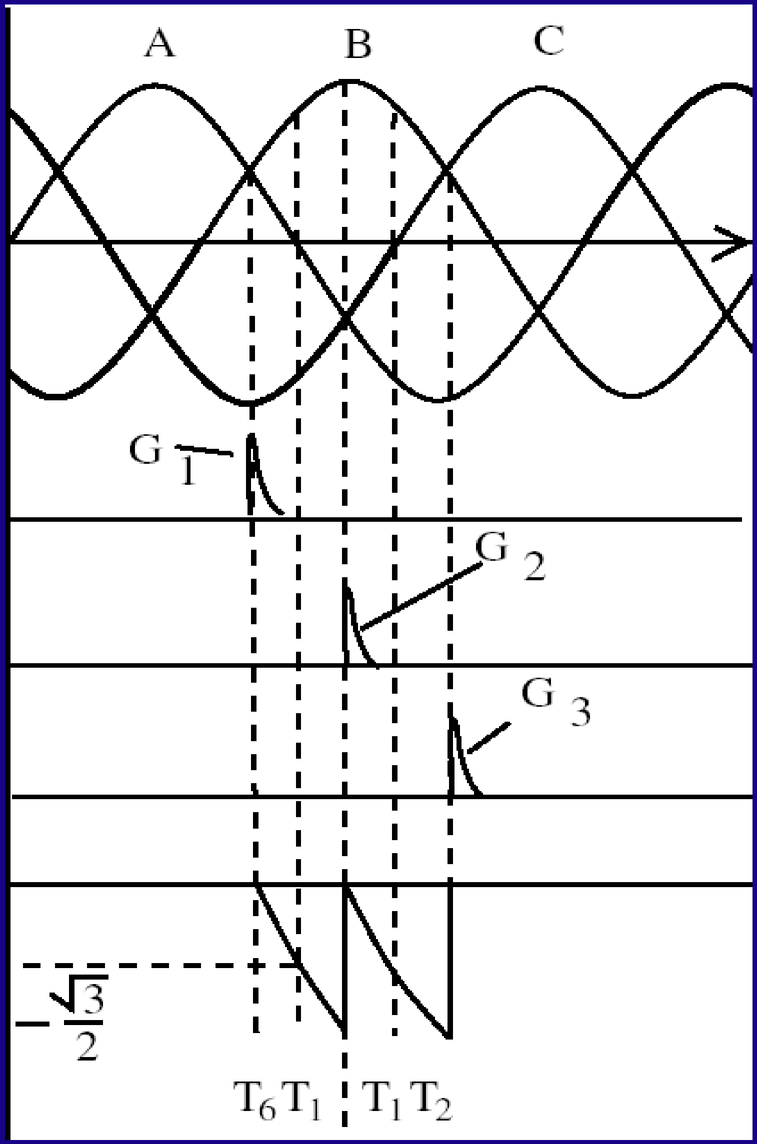
$\therefore V_0 = 0$

at $\omega t = 180$

$V_{an} = 0$

$V_{bn} \ \alpha \ \text{Sin}60 = \sqrt{3}/2$

$\therefore V_0 = -\sqrt{3}/2$



$\text{at } \omega t = 210^{-}$

$V_{an} \ \alpha \ \text{Sin}210 = -1/2$

$V_{bn} \ \alpha \ \text{Sin}90 = 1$

$\therefore V_0 = -1.5$

$\text{at } \omega t = 210^{+} \ , T_2 \text{ is Triggered}$

$V_0 = V_{an} - V_{cn}$

$V_{an} \ \alpha \ \text{Sin}210 = -1/2$

$V_{cn} \ \alpha \ \text{Sin}330 = -1/2$

$\therefore V_0 = 0$

$\text{Observation}: V_0 \text{ is either } 0 \text{ or } -\text{ve}$

What is α_{max} to start the bridge?

$\Rightarrow$ 'α_{max}' For single phase bridge?

can it be 90?

'α' should be $\approx 150-160^\circ$

Depends on 'r' and 'L' in dc side

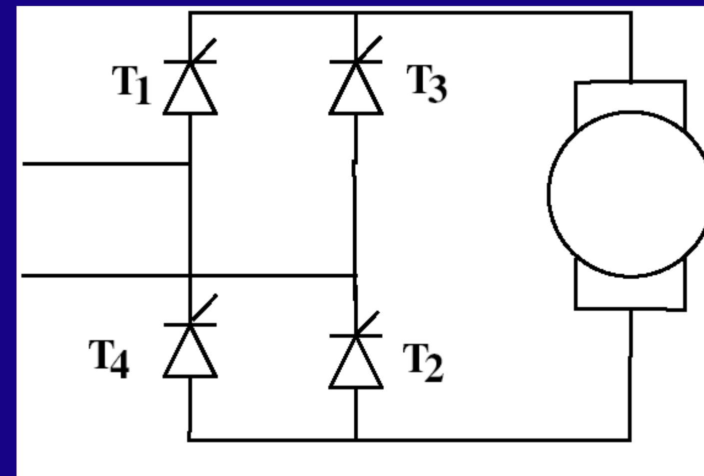
If $> 90^\circ$:

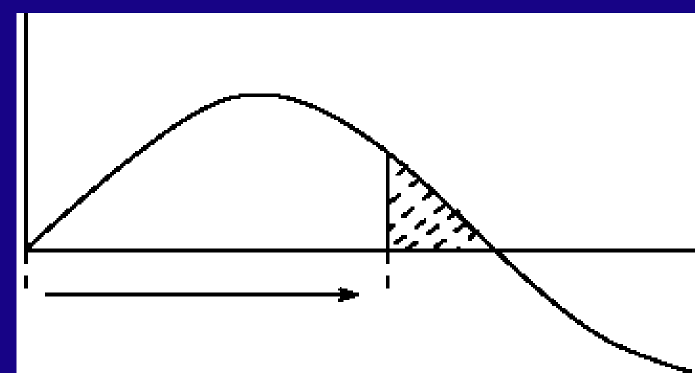
instantaneous value of $V_0 = V_m$

If 'r' & 'L_a' are very small

i_{peak} will be large

$\Rightarrow$ May damage the bridge





In 3 phase :

If $\alpha > 120°$, no current can be established

Because instantaneous value of V_0 is either 0 or $-$ve

$\alpha_{max} < 120°$

So that a $+$ve 'V' appres across 'L' &

'i' starts flowing.

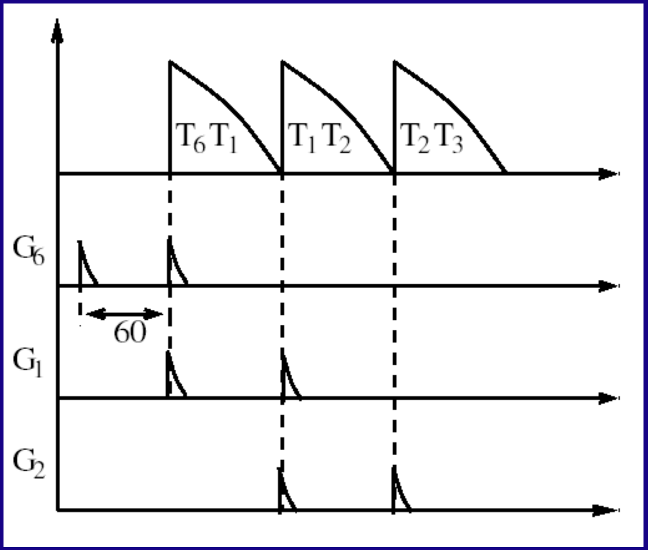
If Load $=$ R

i_L is continuous for $0 < \alpha < 60°$

What is the triggering pulse pattern :

Single phase bridge requires series of pulses for R – L – E load

In 3 phase : At any time two SCRs should be conducting



$\Rightarrow$ Change over from one device to another device does not takes place at same instant in both halves

$\Rightarrow$ To start the bridge or if i_L has becomes zero, to establish 'I' again

2 SCRs should be triggered simultaneously

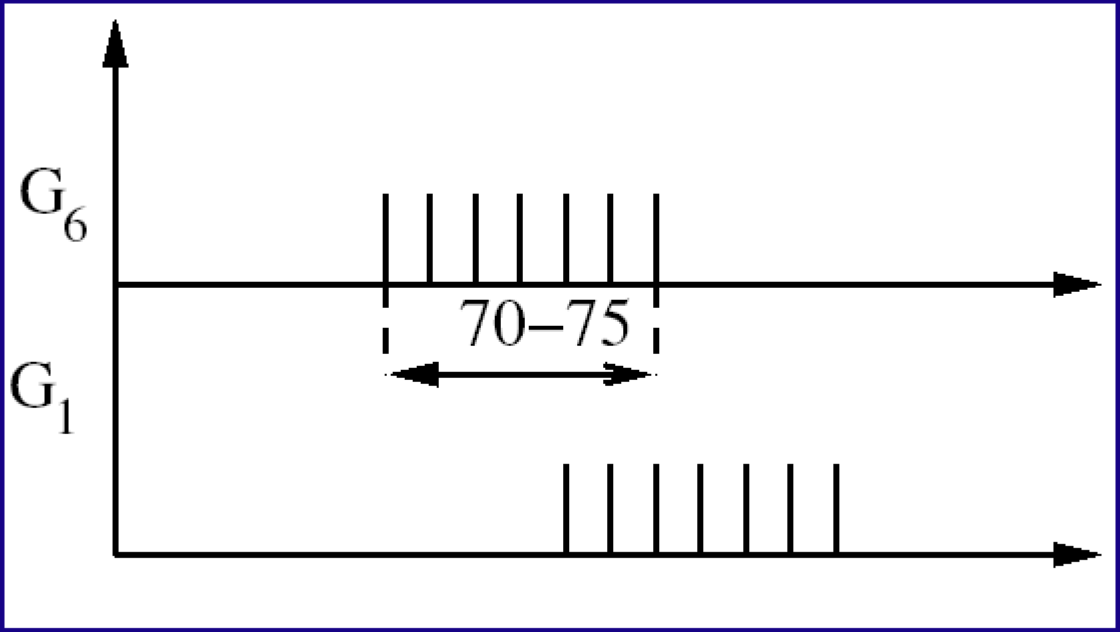
Duration of each pair $= 60°$

$\Rightarrow$ If load is highly inductive $i_{device} > i_{latch}$

When $i_g = 0$

$\Rightarrow$ Have large no. of pulses

of width $70 - 75°$



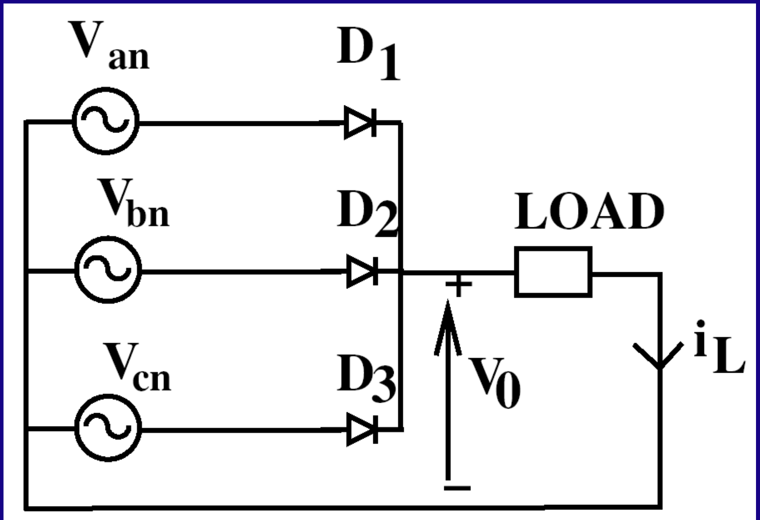
Effect of source L :

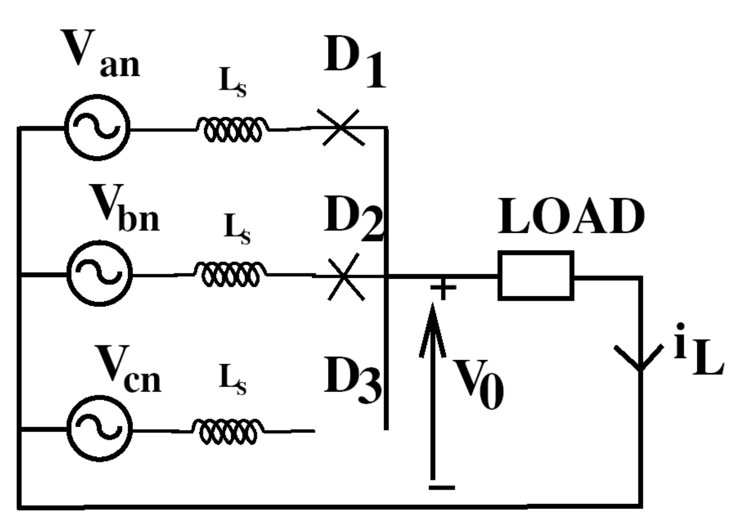
During change any two phases are short circuited

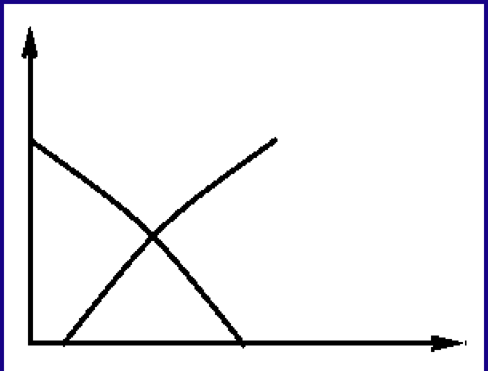
$$V_{an} - V_{bn} = 2L_s \frac{di_s}{dt}$$

Referance for α is the point of natural commutation

$$\therefore V_o = V_{an} - L_s \frac{di_s}{dt}$$







$$V_o = V_{an} - L_s \frac{di_s}{dt}$$

$$= V_{an} - \left\{ \frac{V_{an} - V_{bn}}{2} \right\}$$

$$= \frac{V_{an} + V_{bn}}{2}$$