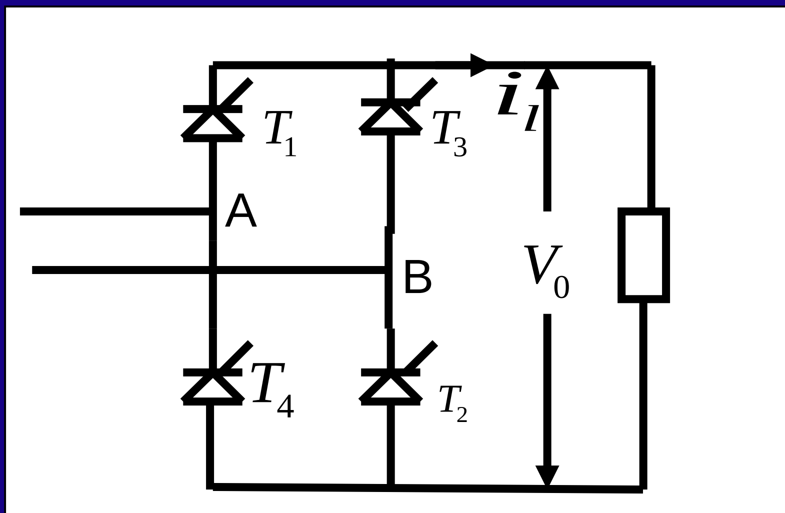
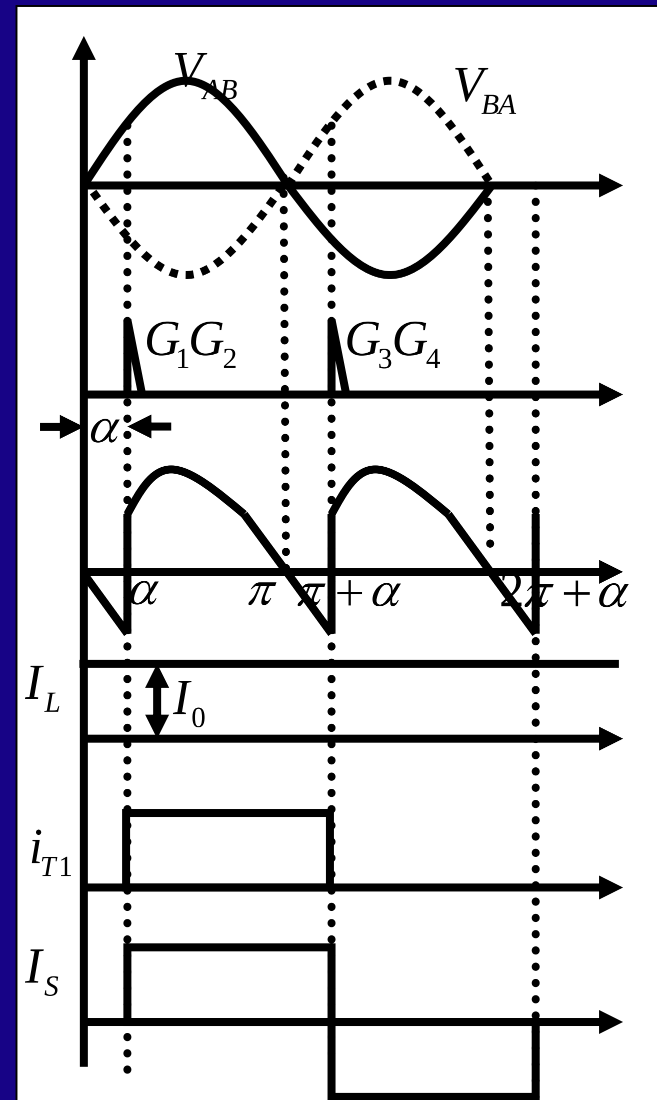
FULL CONTROLLED BRIDGE (Two Quadrant Converter)





- LOAD CURRENT IS CONSTANT & RIPPLE FREE
- IN THE +VE HALF T_1T_2 ARE F.B. & -VE HALF T_3T_4 ARE F.B.

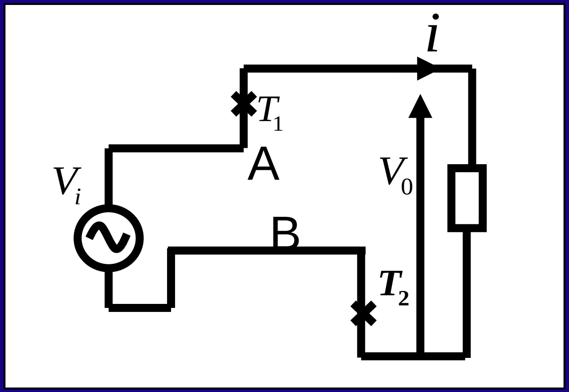
T_1T_2 CONTINUE TO CONDUCT TILL T_3T_4 ARE TRIGGERED
($\because I_0$ IS CONTINUOUS)

α to $(\pi+\alpha)$

$V_0 = V_i = V_m \sin\omega t$

$i_s = I_L$

at $\omega t = \pi + \alpha$ T_3 & T_4 ARE TRIGGERED



POT. OF $A <$ POT. OF C

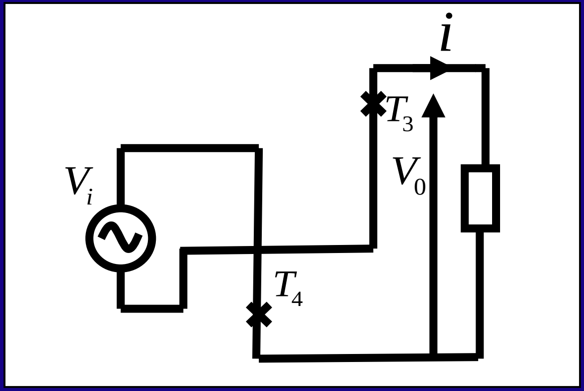
WHEN T_3 STARTS CONDUCTING

$V_K = POT.C$

$\Rightarrow$ -VE 'V' APPEARS ACROSS T_1

$\Rightarrow$ TURNS OFF

$\Rightarrow$ SIMILARLY T_2 TURNS OFF IN THE LOWER ARM



$i_s = i_L$

γ for each device is π rads

There are 2 pulses per cycle $\rightarrow$ Two pulse converter

$$V_0 = \frac{2}{2\pi}\int_{\alpha}^{\pi+\alpha} V_m \sin\omega t\, d\omega t = \frac{2V_m}{\pi}\cos\alpha$$

$\Rightarrow V_0$ +ve For $0 < \alpha < \pi/2$

-ve For $\pi/2 < \alpha < \pi$

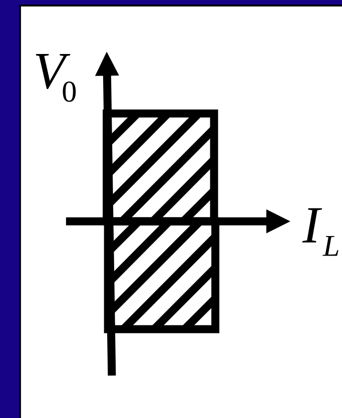
$\Rightarrow I_L$ is unidirectional

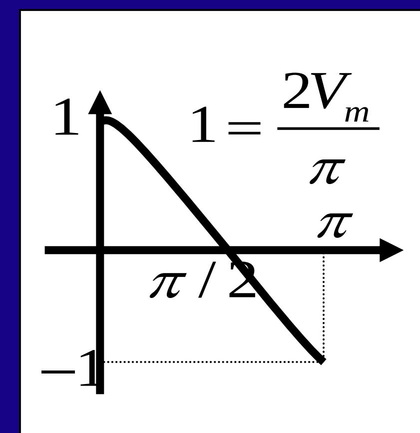
$\Rightarrow 2$ quadrant converter

$\Rightarrow 0 < \alpha < \pi/2$: 1^{st} quadrant operation

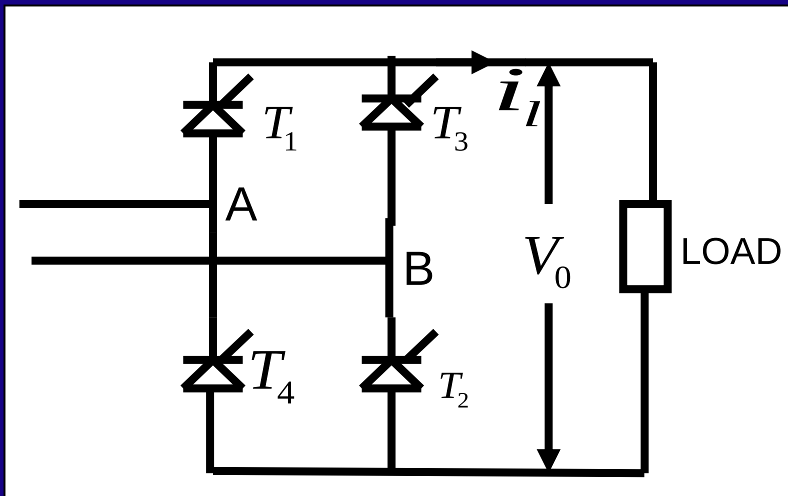
Input Power = +ve → Converter

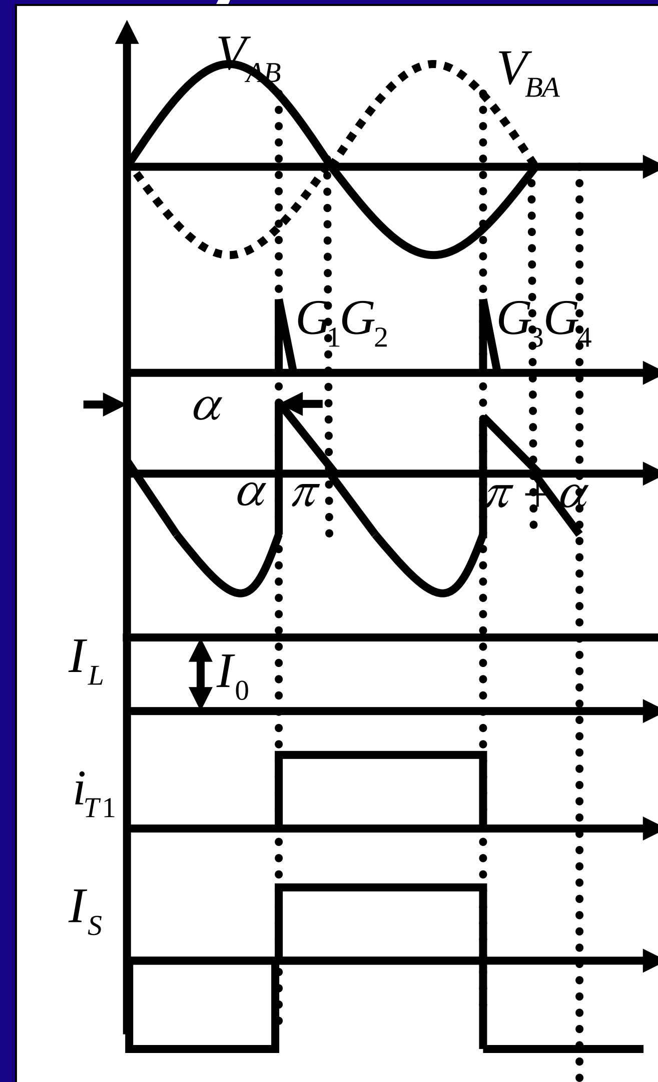
$\Rightarrow \pi/2 < \alpha < \pi$: 4^{th} quadrant operation





FULL CONTROLLED BRIDGE (α > 90)





T_1T_2 are triggered in the +ve half

<u>At steady State</u>

Assume I_L is continuous (constant and ripple free)

T_3T_4 will conduct till T_1T_2 are triggered in the +ve half

In $0<\omega t<\pi$

Pot. of Pt. B < Pot. of Pt. A

$\therefore\ V_0 = V_{BA}$ (–ve)

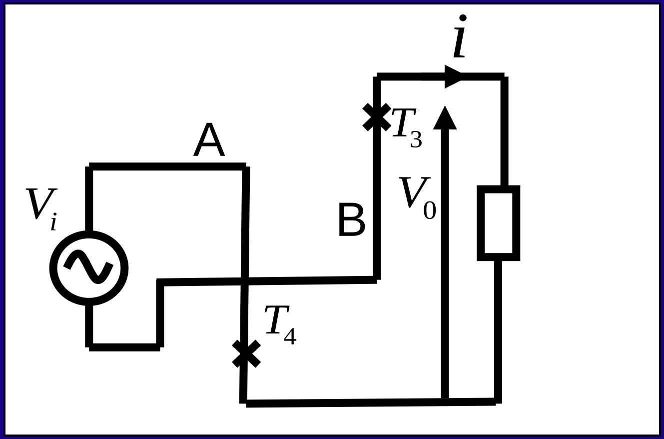
At $\omega t = \alpha^+$ (Immediately after T_1 and T_2 are triggered)

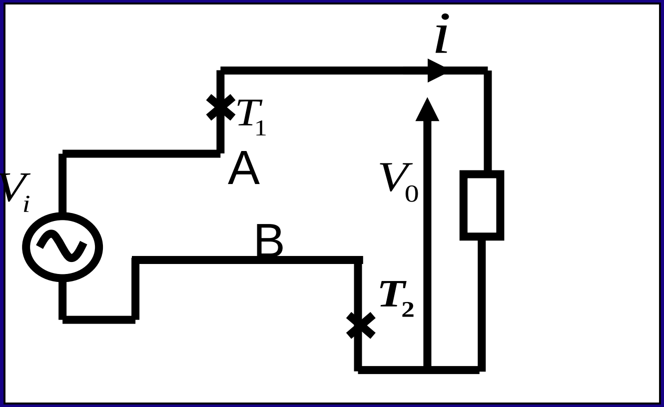
$\Rightarrow T_1\, T_2$ are ON & $T_3\, T_4$ OFF

(Assumed to be instantaneous turn ON and OFF)

$V_0 = V_{AB} \rightarrow +$ ve till $\alpha<\omega t<\pi$

$\rightarrow$-ve for $\pi<\omega t<\alpha+\pi$





Input Power=-ve → Inversion

$$\theta_1 = \alpha$$

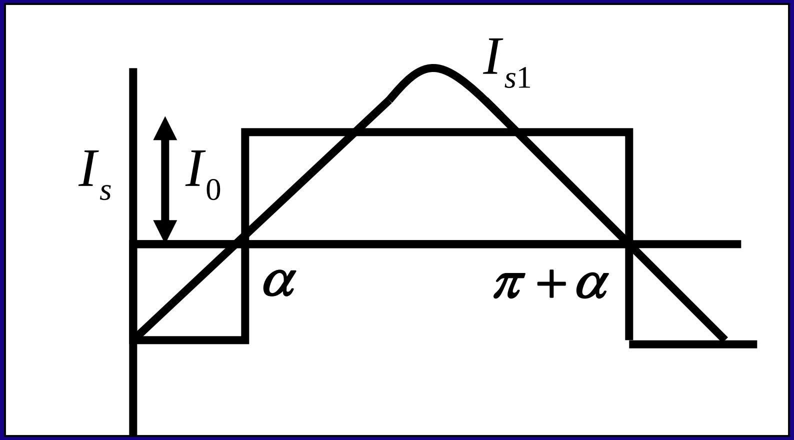
$Cos\theta_1 = Cos(-\alpha)$ (lagging)

$$I_{rms}\ of\ I_{s1} = \frac{2\sqrt{2}}{\pi} I_0$$

$$RMS\ value\ of\ I_s = I_0$$

$$P.F. = \frac{2\sqrt{2}}{\pi} Cos\alpha = \frac{V_{s1} I_{s1} Cos\alpha}{V_{rms} I_{rms}} = \frac{2\sqrt{2}}{\pi} Cos\alpha$$

$\rightarrow lagging$



What sort of a load ?

Assuming that 'I_L' is continuous

$$\Rightarrow \text{ Avg. } V_0 = \frac{2V_m}{\pi}\cos\alpha \text{ is valid}$$

$$\text{if '}I_L\text{' is discontinuous } V_0 \neq \frac{2V_m}{\pi}\cos\alpha$$

$\Rightarrow$ Avg. value of V_0 is determined

by integrating the o/p 'V_0'

[ouput V_0 now dependent on load]

Avg. $V_0 \rightarrow$ -ve

I_L = always +ve (can not reverse)

$\because$ SCR`s are unidirectional

Avg. Power I/P = $V_{o(avg)} I_{L(avg)}$

<u>For Load = R</u>

I/P Power = always +ve

Consumes power $\rightarrow$ dissipates as heat

<u>For Load = L</u>

For steady state $\left(L\frac{di}{dt}\right)_{avg} = 0$

If $\left(L\frac{di}{dt}\right)_{avg} > 0 \rightarrow \frac{di}{dt}$ is $\uparrow$

(recall Full wave diode rectifier feeding pure 'L' load, 'i' goes on $\uparrow$ till ....)

$\left(L\frac{di}{dt}\right)_{avg}$ can never be -ve

$\Rightarrow$ if load is passive = $V_{o(avg)} I_{L(avg)} \geq 0$

$\Rightarrow$ If the load is R-L-E

Either a battery or a DC- motor

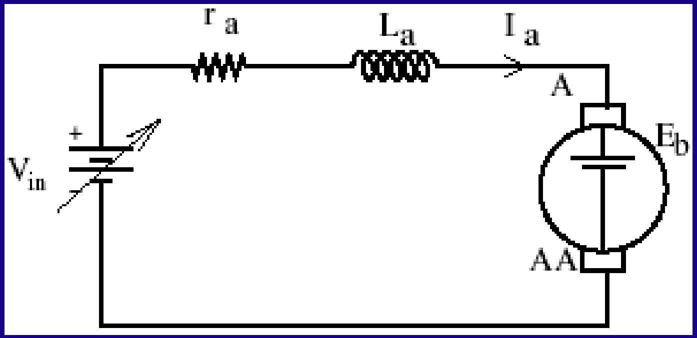
$\Rightarrow$ Power can be fed back to the source

Both can supply or absorb power.

For DC-motor: If power i/p is +ve $\Rightarrow$ motor

if power i/p is -ve $\Rightarrow$ generator

For the m/c : To operate as a generator 'I_a' should leave terminal 'A'(It enters 'A' during motoring)



If $|E_b| > |V_{in}|$

$\Rightarrow$ 'I_a' leaves 'A' terminal

For the Converter fed DC machine :

'I' can not reverse but 'V' can reverse.

$T_e \rightarrow$ - ve $\rightarrow$ either 'ϕ' or 'I_a' should reverse

Consider DC M/C :-

Developed Torque $T_e = K\varphi I_a$

$$\frac{d\omega}{dt} = \left(\frac{T_e - T_L}{J}\right)$$, T_L is load torque.

⇒ Assume that motor has attained a steady state and running at ω.

⇒ Want to stop the motor

Case I: Switch off the supply to the motor

$$T_E = 0$$

⇒ $-\frac{d\omega}{dt}$ depends on mechanical time constant

$$\tau_m = \frac{J}{B}$$

Stored energy is dissipated as heat

$\Rightarrow$ How to $\uparrow -\dfrac{d\omega}{dt}$

$\Rightarrow$ Make T_e -ve

$$\frac{d\omega}{dt} = -\frac{(T_e + T_L)}{J}$$

$\Rightarrow$ Faster deceleration

$\Rightarrow T_e \rightarrow$ -ve

Sign Convention:

+ve for motoring

-ve for Generating

$\Rightarrow$ Energy is fedback to the source

$\Rightarrow$ Regenerative breaking

For I_a reversal:

Interchange armature terminals

$\Rightarrow$ i/p to the bridge is −ve

$\Rightarrow$ Motor current has reversed

$\Rightarrow$ m/c is operating like a generator

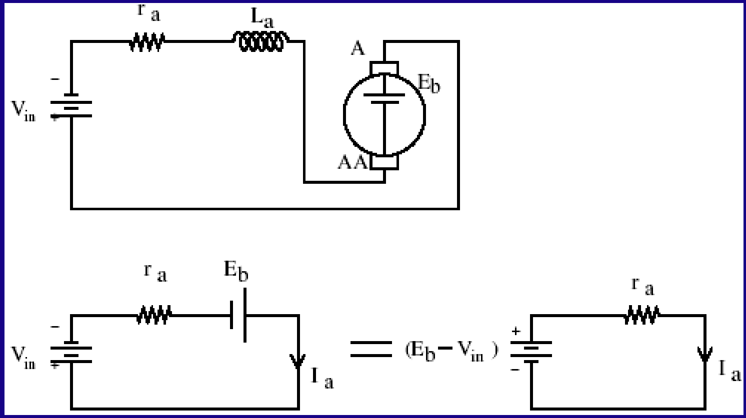
$\Rightarrow$ No mechanical i/p

$\Rightarrow \therefore$ speed & $\therefore E_b \downarrow$

$\Rightarrow$ In order to maintain constant I_a

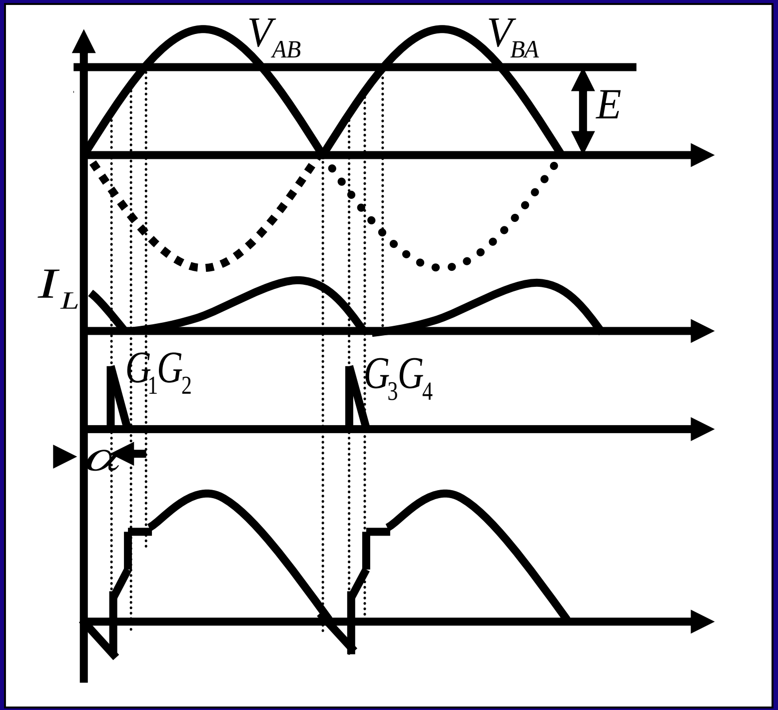
$\downarrow V_{in}$

$\Rightarrow \downarrow \alpha$ towards 90°



Discontinuous Conduction : R-L-E Load

Case I :



'i' is finite

When $T_1 T_2$ are triggered

T_3 & T_4 were conducting

Instantaneous V_0 *is* -ve($\because$ is V_{BA})

$\rightarrow T_1$ & T_2 are triggered at 'α'

$V_i < E \;\therefore \dfrac{di}{dt}$ is -ve

$\rightarrow$ 'i' becomes zero before $\omega t = \sin^{-1}(\dfrac{E}{V_m})$

$\rightarrow$ *Till 'i'* is present , $V_0 = V_i$

From the instant i=0 till $\omega t = \sin^{-1}(\frac{E}{V_m})$

$V_0 = E$

Beyond this instant SCR`s are F.B

$\rightarrow$ If gate pulse is present it starts conducting from this instant

Case II :

$$\alpha > \sin^{-1}\left(\frac{E}{V_m}\right)$$

$$I_L = 0 \quad 0 < \omega t < \sin^{-1}\left(\frac{E}{V_m}\right)$$

Prior to triggering $T_1 T_2$,

$T_3 T_4$ were conducting

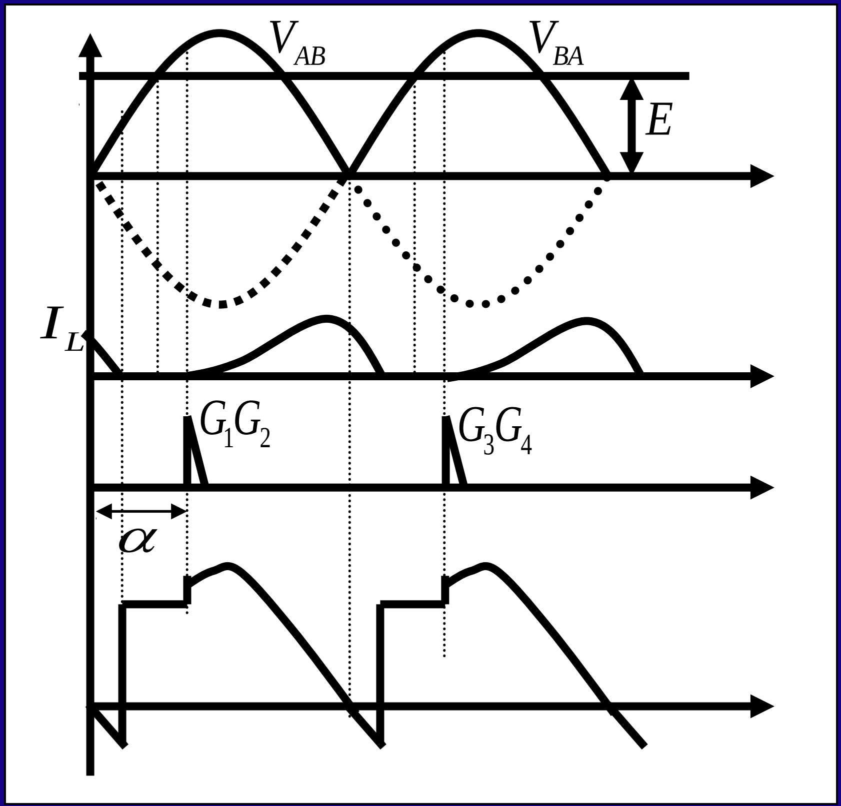
till $I_L = 0$,

$V_i = V_{AB}$ (−ve in the +ve half)

From this instant to α, $V_0 = E$

At 'α', T_1 & T_2 are conducting,

$V_0 = V_m \sin\alpha > E$



Case *I*:

$\alpha > 90°$

Can I_L be continuous ?

$\Rightarrow$ If I_L is continuous

$$V_0 = \left(\frac{Ldi}{dt}\right)_{av} = -\text{ ve}$$

$\Rightarrow$ Not possible

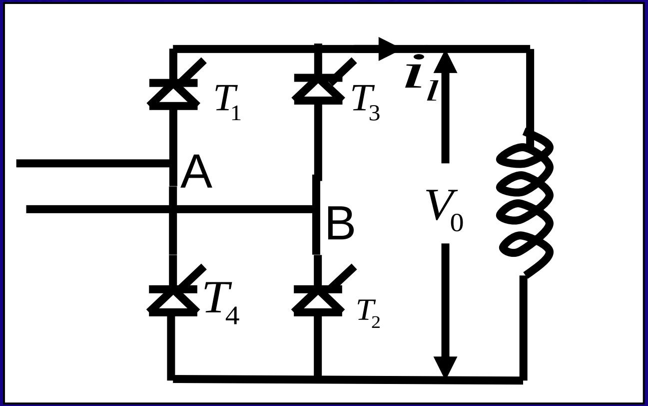
$\Rightarrow$ If $\alpha = 110°$

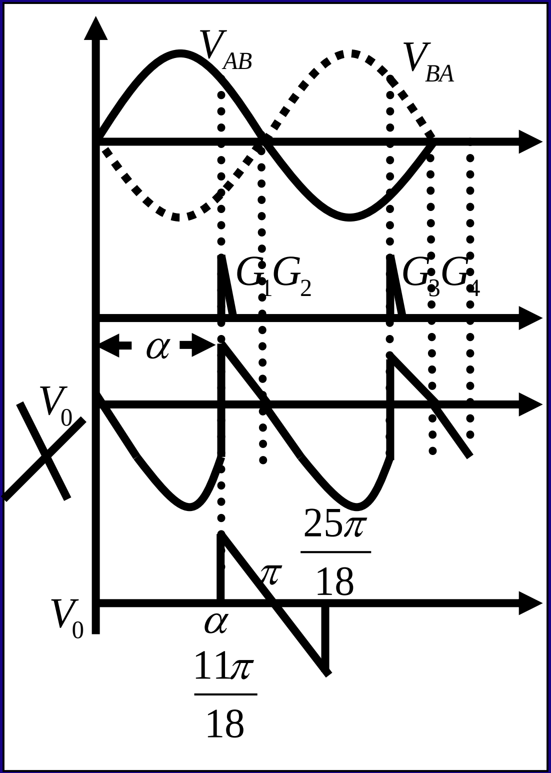
T_1 T_2 will turn off($\because i_L = 0$)

at $180 + 70 = 250°$

$\Rightarrow$ I_L is just continuous at $\alpha = 90°$

$$\text{Av } V_0 = \frac{2V_m}{\pi}\text{Cos}\,\alpha = 0$$





$\alpha < 90°$

I will be continuous till

Av V_0=+ve

$\Rightarrow \left(L \frac{di}{dt} \right)_{av}$ =+ve

No steady state

I goes on ↑ till......