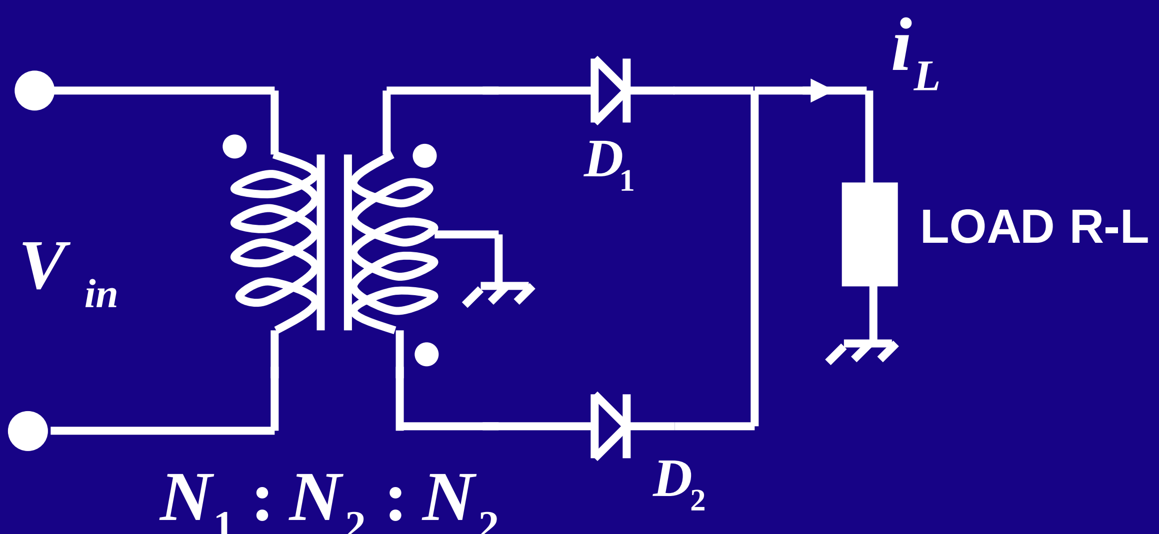
FULL WAVE RECTIFICATION

IN HALF WAVE :

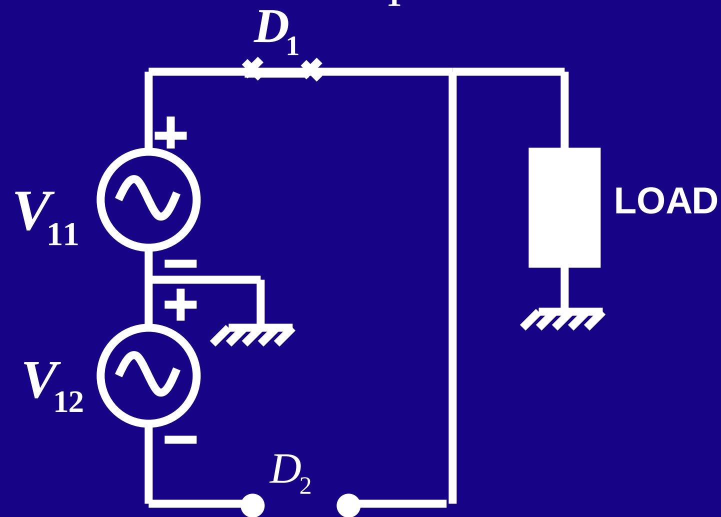
- APPLIED 'V' TO THE LOAD IS '0' OR '-VE' BEYOND π
- RIPPLE IN THE OUTPUT 'V' INCREASES
- USE FULL WAVE RECTIFICATION

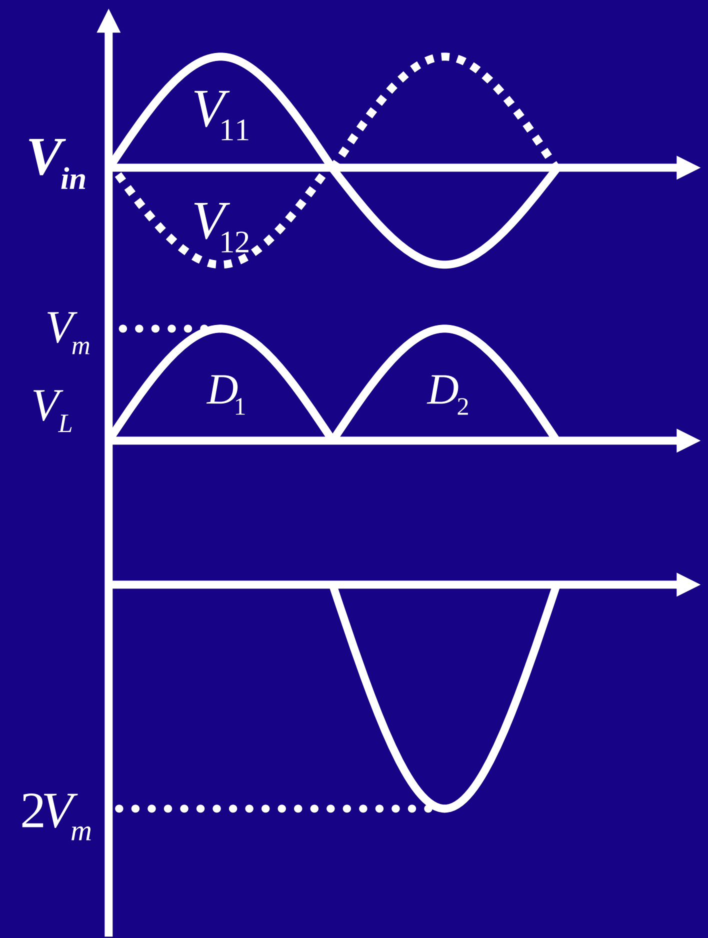
USING CENTRE TAPPED TRANSFORMER

POPULAR IN POWER SUPPLIES



In the +ve HALF D_1 Conducts





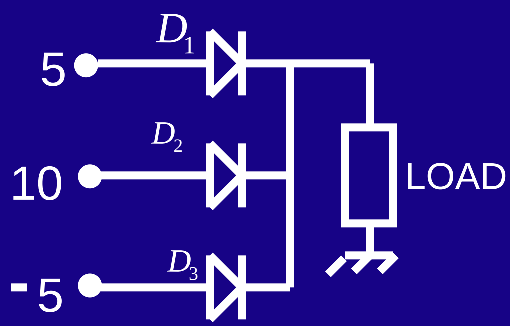
$$V_{D2} = -(V_{11} + V_{12})$$

$$V_{D2(\max)} = -2V_{11\,(\max)}$$

$$V_{11} = \left(\frac{N_2}{N_1}\right)V_{in}$$

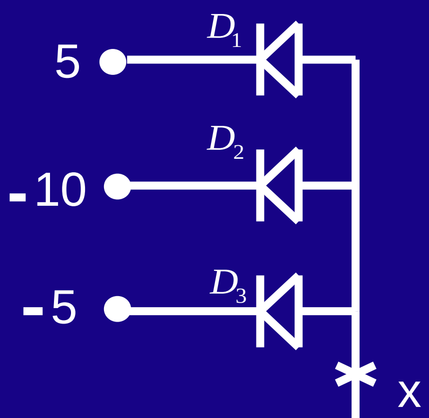
AV. O / P $\quad V = \dfrac{2V_m}{\pi}$

CONSIDER: **A COMMON CATHOD CONFIGURATION**



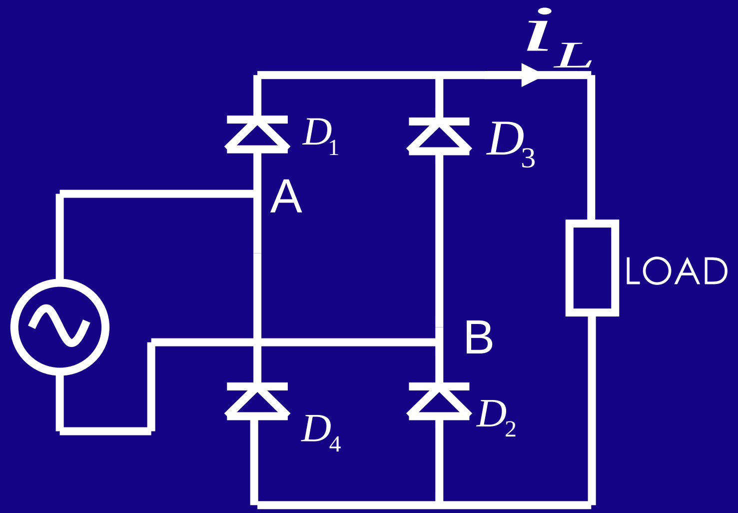
- **ONLY D_2 CAN CONDUCT**
- **DIODE WHOSE ANODE POTENTIAL IS HIGHEST WILL CONDUCT**

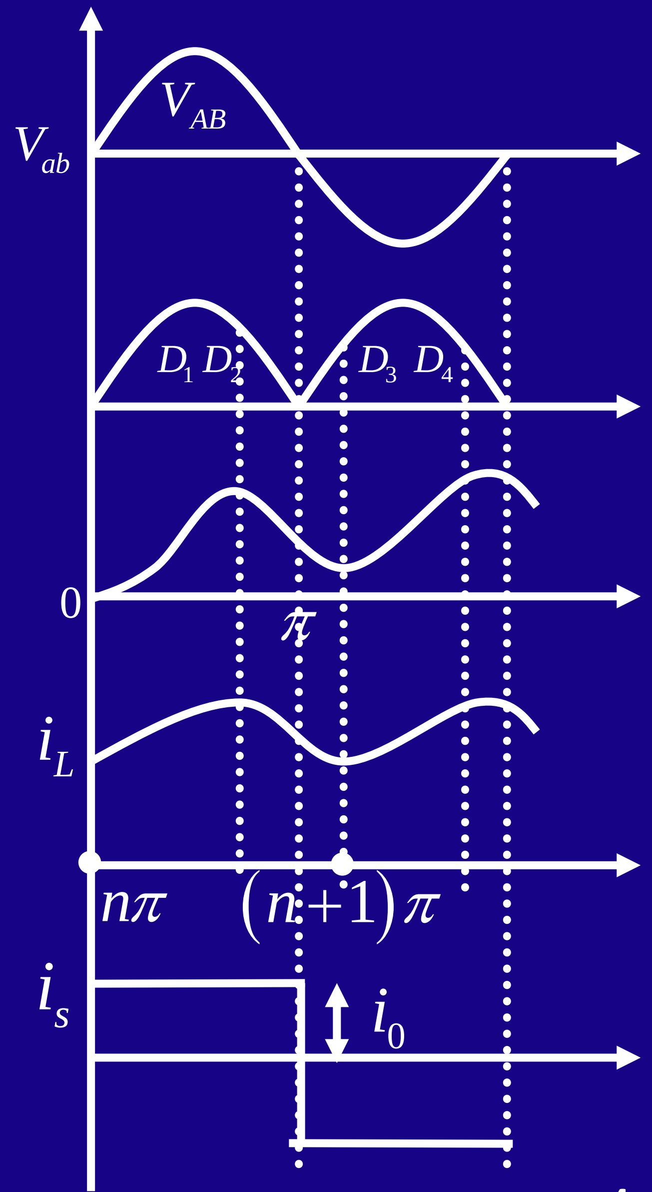
A COMMON ANODE CONFIGURATION



- **POTENTIAL OF x CAN BE -10V**
- **ONLY D_2 CAN CONDUCT**
- **DIODE WHOSE CATHOD POTENTIAL IS MINIMUM WILL CONDUCT**

SINGLE PHASE BRIDGE





D_1 D_3 ➡ COMMON CATHOD CONFIGURATION

D_2 D_4 ➡ COMMON ANODE CONFIGURATION

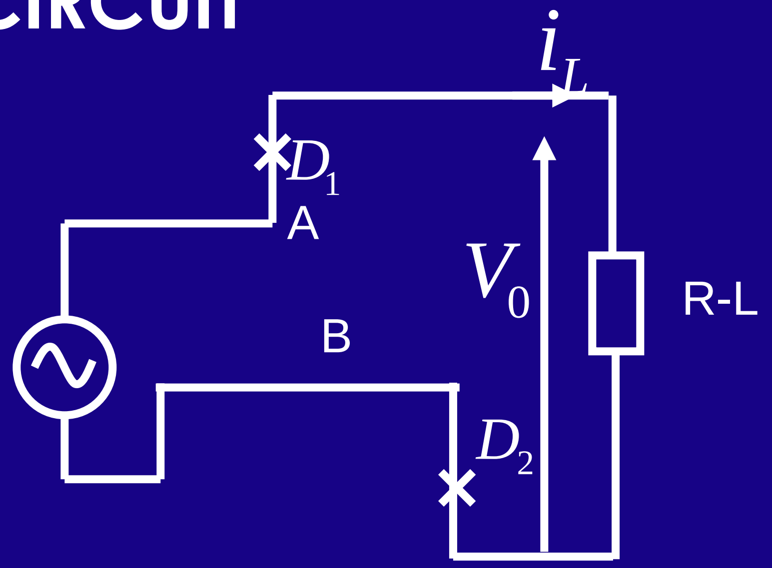
IN +VE HALF

POT. OF A > POT. B

D_1 WILL CONDUCT IN THE UPPER HALF

D_2 WILL CONDUCT IN THE LOWER HALF

EQUIVALENT CIRCUIT



$$V_m \sin \omega t = Ri + L\frac{di}{dt}$$

$$i = \frac{Vm}{Z}\left[\sin\left(\omega t - \varphi\right) + \sin\varphi e^{-t/\tau}\right]$$

$$i = i_{\max} \qquad \pi/2 < \omega t < \pi$$

$$v_i = Ri_{\max} \qquad \because\ L\frac{di_{\max}}{dt} = 0$$

At $\omega t = \pi^+$, D_3 & D_4 starts conducting.

+ve V is applied to the load.

At steady state if load is highly L i_0 becomes almost constant.

Whenever Diode conducts source $I =$ Load I

$\Rightarrow$ For analysis assume that i_L is constant & ripple free.

$\Rightarrow$ Source I is square wave

$\Rightarrow$ Odd function

$\Rightarrow$ Fourier series will have all odd component

Peak of 1st or Fundamental component $= \dfrac{4I_0}{\pi} = b_1$

Displacement Angle $\theta_1 \ \angle_{V_i}^{b_1} = 0$

Displacement Factor $= \cos\theta_1 = 1$

Input power factor :

$$\text{P.F} = \frac{\text{Mean i/p power}}{\text{R.M.S. Input VA}}$$

$\Rightarrow$ only fundamental component of i/p I contributes to mean i/p power.

$\Rightarrow$ other components contribute to heat $(I^2R$ loss)

$$P.F. = \frac{V_1 I_1 \cos\theta_1}{V_{rms} I_{rms}}$$

$\Rightarrow$ supply is a pure sinusoid.

$\Rightarrow V_1 = V_{rms}$

$\Rightarrow$ Source I is a square waveform.

$\Rightarrow$ $3^{rd}, 5^{th}, 7^{th}$ Harmonics

$$I_{rms} = I_0 \qquad I_1 = \frac{4I_0}{\sqrt{2}\pi} \qquad \cos\theta = 0.9\ lag$$

$\Rightarrow$ Decides the VA requirement

T.H.D. $= \dfrac{\text{Ripple}}{\text{Fundamental}} = \dfrac{(I_{rms}{}^2 - I_1{}^2)^{1/2}}{I_1} \approx 49\%$

LOAD IS PURE L :–

In the +ve Half $L\dfrac{di}{dt}=V$

$i = i_{max}$ at $\omega t = \pi$,

At $\omega t = \pi^+$

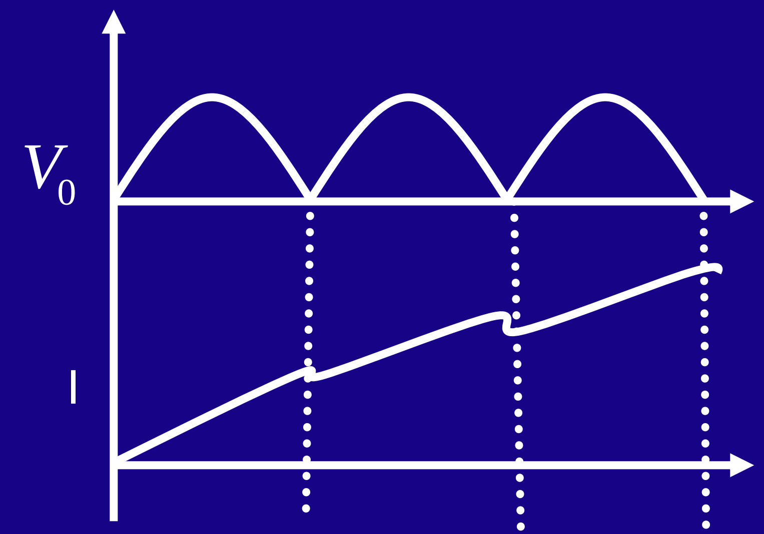
+ve V is again applied to the Load

i $\uparrow$ continuously

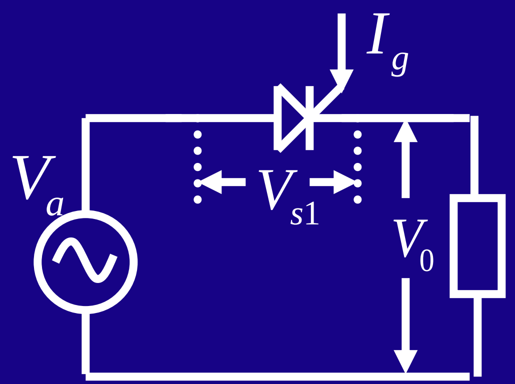
$\Rightarrow$ No steady state

$\Rightarrow$ V across L = $+ve$

$\Rightarrow \dfrac{di}{dt}$ is $+ve$



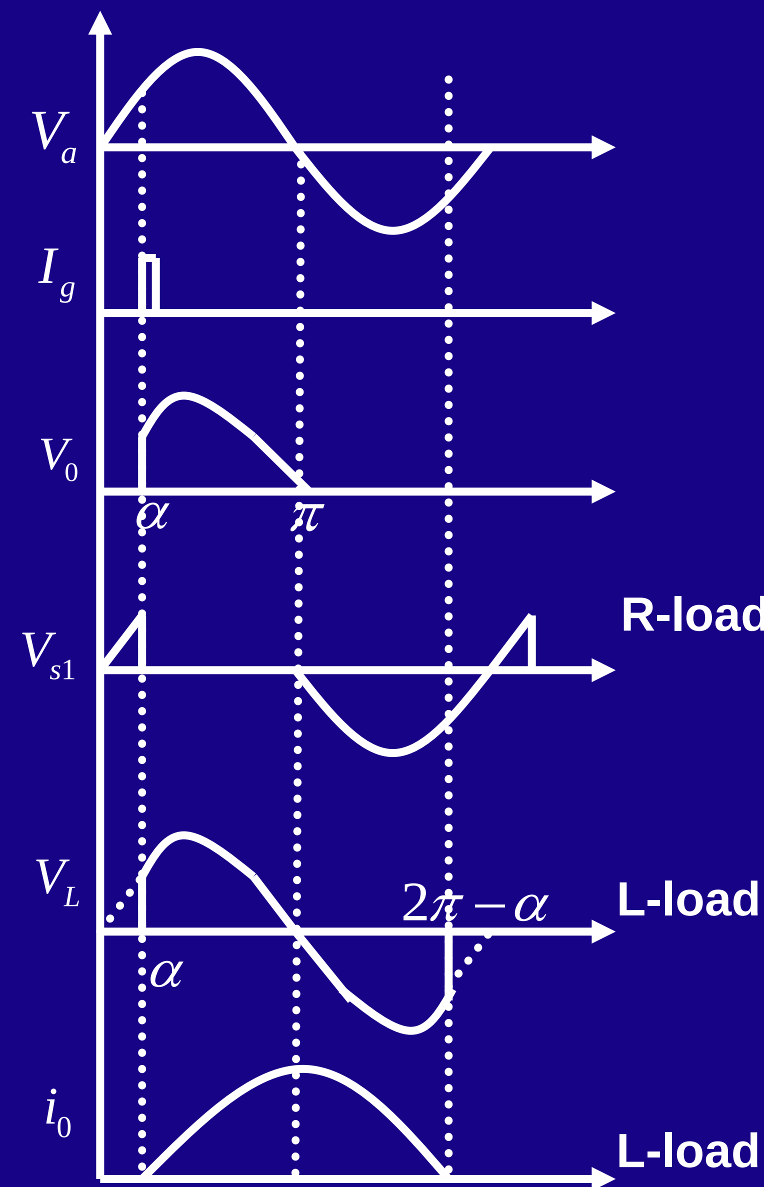
CONTROLLED RECTIFICATION



SCR (THYRISTOR) IS USED

- CAN BE TURNED 'ON' BY APPLYING GATE SIGNAL WHEN IT IS F.B.
- OPERATION IS ALMOST THE SAME AS THAT OF 'D' CIRCUIT
- IF LOAD I IS CONTINUOUS, $\alpha_{\min} = 0$

& IS INDEPENDENT OF TYPE OF LOAD



HALF CONTROLLED BRIDGE

ASSUMING: i_l CONST. AND RIPPLE FREE

POSSIBLE IF 'L' IS HIGH

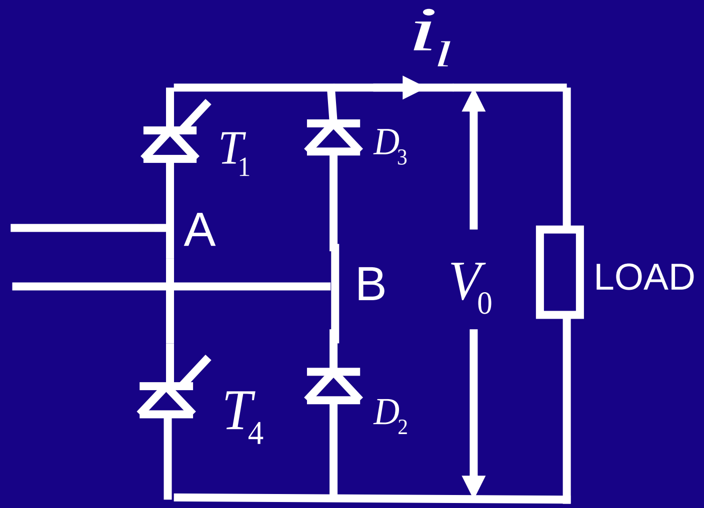
ASSUME 'L' ON SOURCE SIDE IS = 0

SCR TURNS OFF IMMEDIATELY WHEN

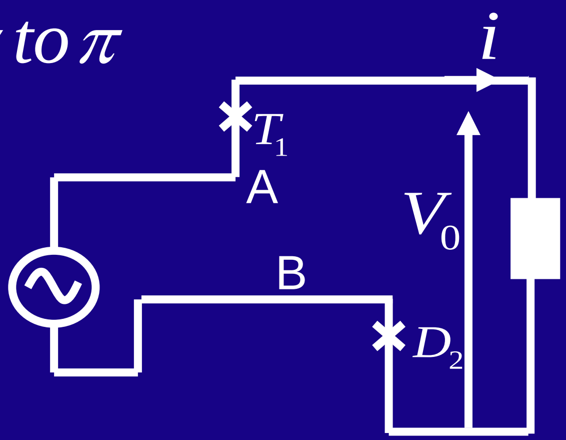
–VE VOLTAGE IS APPLIED ACROSS IT

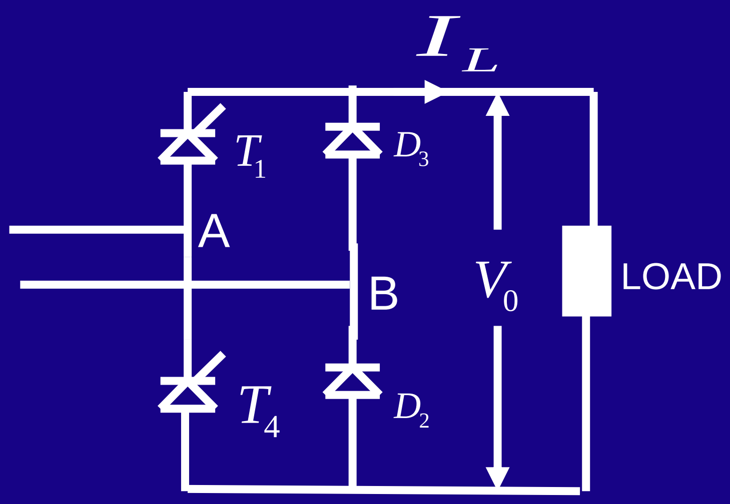
AT $\omega T = \alpha$ T_1 IS TURNED ON

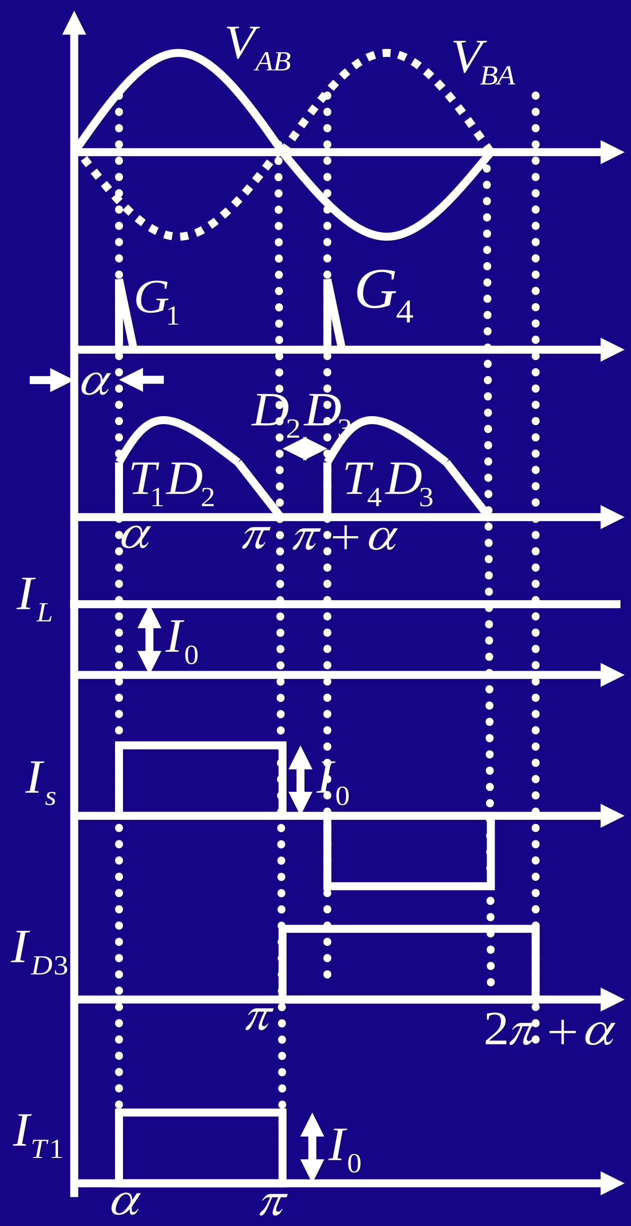
AT $\omega T = \pi + \alpha$ T_4 IS TURNED ON



FROM α to π




I_L
T_1
D_3
A
B
V_0
LOAD
T_4
D_2


V_{AB}
V_{BA}
G_1
G_4
α
D_2D_3
T_1D_2
T_4D_3
α
π
$\pi+\alpha$
I_L
I_0
I_s
I_0
I_{D3}
π
$2\pi+\alpha$
I_{T1}
I_0
α
π

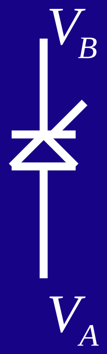
At $\omega t = \pi^{+}$

Potential (Pot.) of B > Pot. of A

Upper half :- Common cathode configuration

$\Rightarrow$ Doide D_3 starts conducting

$\Rightarrow$ Cathode Pot. of T_1 =Pot. of B



$\Rightarrow$ -ve V across T_1

$\Rightarrow$ T_1 Turns off

$\Rightarrow$ Line Commutation

Lower Arm:

$\Rightarrow T_4$ is F.B.

$\Rightarrow$ Gate signal is applied only at $\pi+\alpha$

$\Rightarrow$ From π to $\pi+\alpha$ T_4 is <u>O.C.</u>

$\Rightarrow D_2$ continues to conduct

$\Rightarrow$ Load is free wheeling through D_2 - D_3

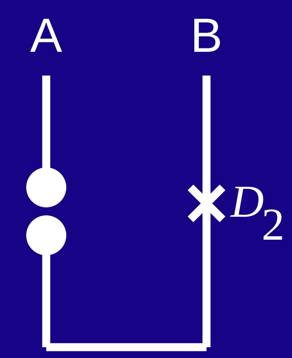
$\underline{V_0 = 0}$ Source $I = 0$

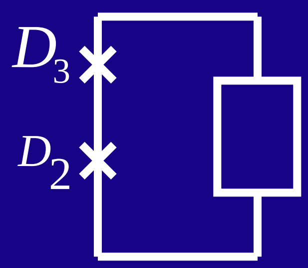
$\Rightarrow$ Continues till $\pi+\alpha$ while T_4 is Triggered

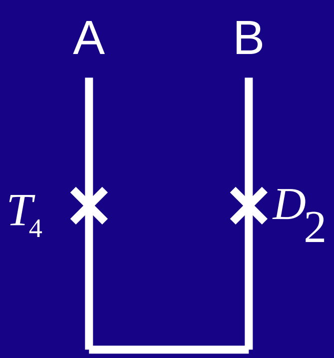
$\Rightarrow \because$ It is F.B. & gate signal present

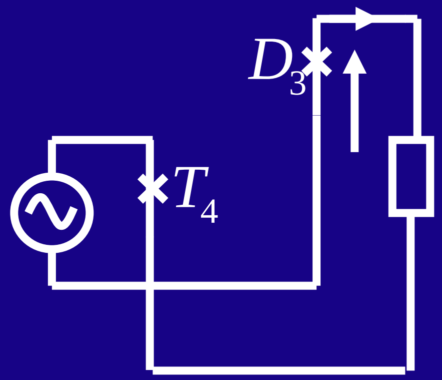
T_4 starts conducting

$\Rightarrow$ Applied -ve 'V' across $D_2 \Rightarrow D_2$ turns off









$\Rightarrow$ From $\pi + \alpha$ to 2π

$\Rightarrow$ Operation is similar to that of α to π

Only direction of I_s has reversed

$\Rightarrow$ From 2π to $2\pi + \alpha$

$\Rightarrow$ Operation is similar to that of π to $\pi + \alpha$

$\Rightarrow T_4$ & D_2 form common anode config.

$\Rightarrow D_2$ starts conducting

$\Rightarrow$ Applies -ve 'V' across T_4

T_4 turns off

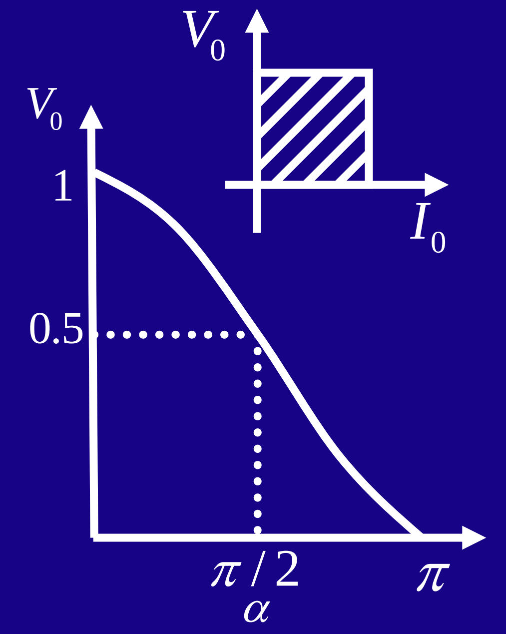
$\Rightarrow$ Upper half : T_1 is not triggered

$$V_{av} = \frac{V_m}{\pi}\left(1+\cos\alpha\right)$$

$\Rightarrow V_{av}$ is always <u>+ve</u>

$\Rightarrow$ Load I is always unidirectional

$\Rightarrow$ Single Quardrant Converter $\quad 1 = \dfrac{2V_m}{\pi}$



Displacement Factor $= Cos\left(-\dfrac{\alpha}{2}\right)$

Lagging : RMS value of the fundamental component source I_s

$$I_s = \frac{2\sqrt{2}}{\pi} I_a Cos\left(\frac{\alpha}{2}\right) \qquad P.F = \frac{\sqrt{2}\left(1-Cos\alpha\right)}{\left[\pi\left(\pi-\alpha\right)\right]^{1/2}}$$

Observation:

$\Rightarrow If\ \alpha \neq 0 \qquad \gamma\ \ for\ T \neq \gamma\ \ for\ \ D$

$\Rightarrow$ **Av.Current rating of T < Av. Current rating of D**

Case II: Operation α to π is same

$$V_0 = V_{in}$$

From π to $\pi + \alpha$

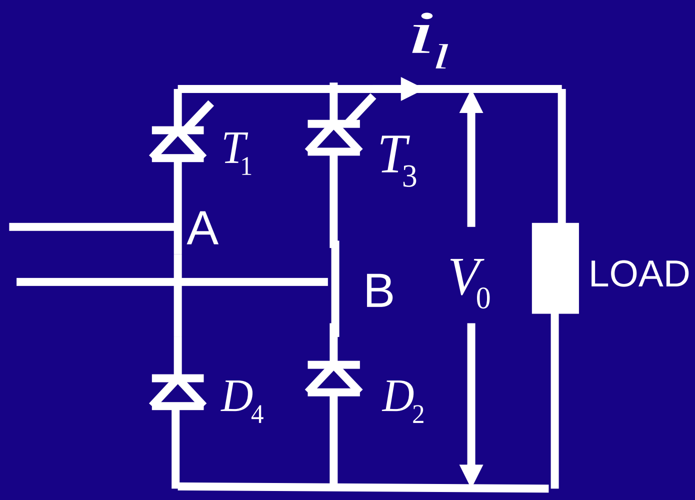
Lower arm common Anode config.

D_4 starts conducting

In Upper half T_3 F.B.

$\Rightarrow$No triggering pulse (Gets only at $\pi + \alpha$)

Till then it can not conduct



$\Rightarrow I_L$ freewheels through T_1 & D_4

$I_S = 0,\ V_0 = 0$

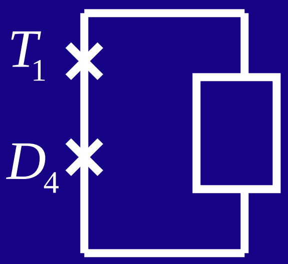
$\Rightarrow$ At $\pi + \alpha : T_3$ is triggered

$\Rightarrow$ Starts conducting

$\Rightarrow$ Applies -ve 'V' across T_1

$\Rightarrow$ Turns off

$V_0 = V_{in}$



From 2π to $2\pi+\alpha$ (or 0 *to* α)

Pot. of A > Pot. of B

$\Rightarrow D_2$ starts conducting

(C.A. config.)

$\Rightarrow D_4$ turns off

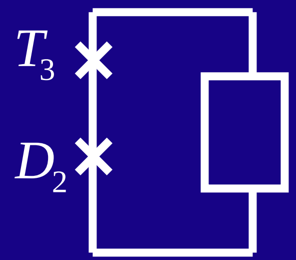
$\Rightarrow T_1$ starts conducting

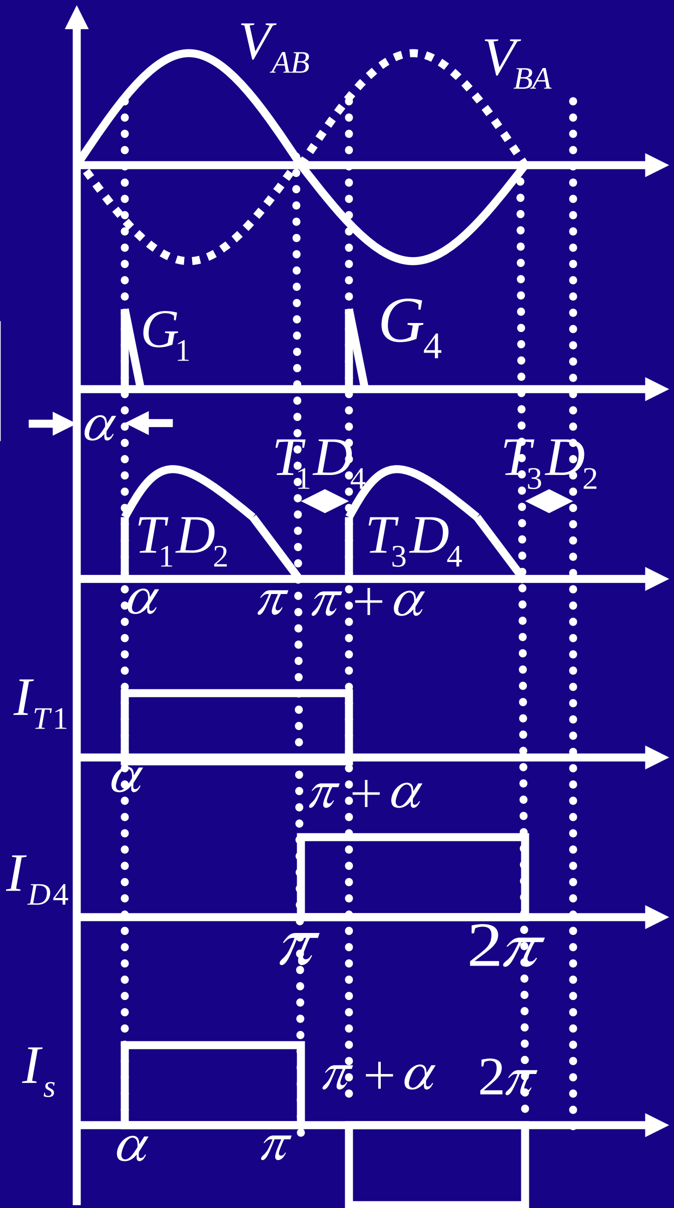
only at $2\pi+\alpha$ (or α)

γ for $T=\gamma$ for D

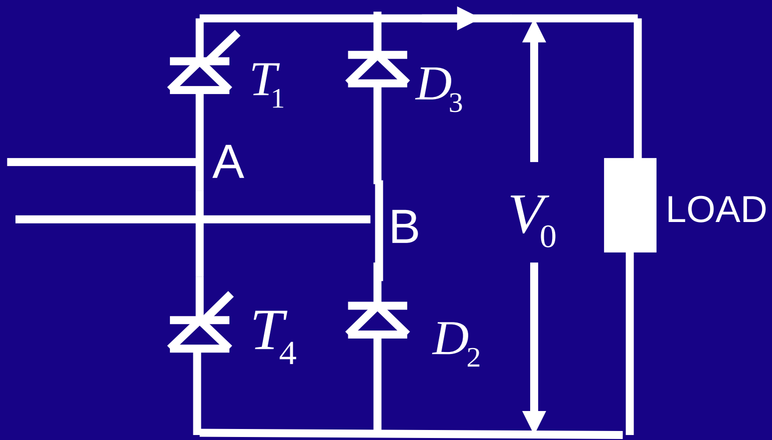
Av. I of T = Av. I of D

$$V_0=\frac{V_m}{\pi}(1+Cos\alpha)$$

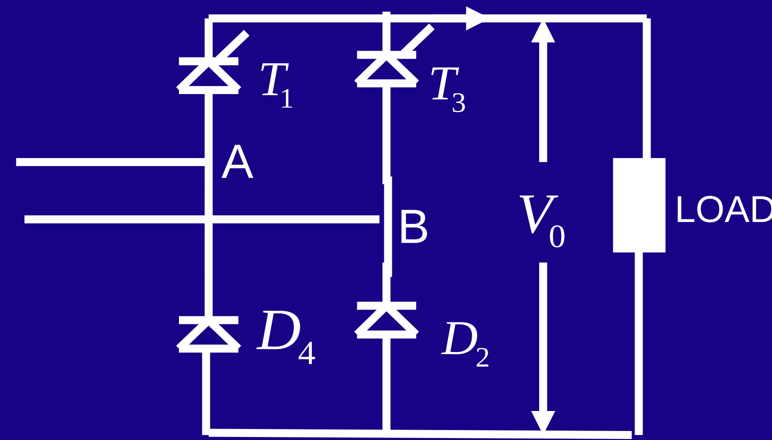




CASE I



CASE II



- DEVICE SHOULD ATTAIN THE FORWARD BLOCKING CAPABILITY BEFORE IT IS F.B.
- OTHERWISE IT WILL NOT TURN OFF
  - COMMUTATION FAILURE

<u>IN CASE I</u>

AT $\omega T = \pi^{+}$, T_1 IS TURNED OFF

BECAUSE DIODE STARTS CONDUCTING

- CASE II
- T_1 CONTINUES TO CONDUCT TILL T_3 IS TRIGGERED
  T_3 CAN BE TURNED OFF ONLY BY TURNING ON T_1
- IF $\underline{\alpha \to \pi}$
- BEFORE $\omega t = \pi^+ \to T_3$ GETS FORWARD BAISED
- T_3 SHOULD ATTAIN ITS F.B.
  CAPABILITY BEFORE $\omega t = \pi^+$
- REQUIRES FINITE TIME
- IF AVAILABLE TIME < THE ABOVE TIME
  T_3 CONTINUOUS TO CONDUCT
- ½ WAVE EFFECT