HVDC Link Control Schemes:

R: CIA, CC, VDCOL

I: CEA, $C\beta$, CC, VDCOL

$\alpha \rightarrow$ delay angle

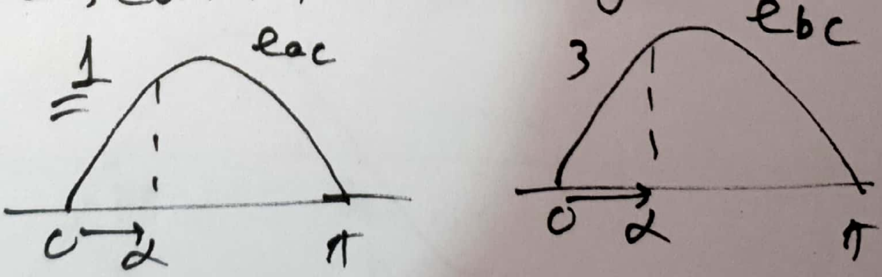
Types of control schemes:

- Individual Phase control (IPC)
- Equidistant Pulse control (EPC)

i) **IPC Technique:-** In this control technique the firing instant of each valve is determined individually.

$\rightarrow$ commutation voltage

Ex.

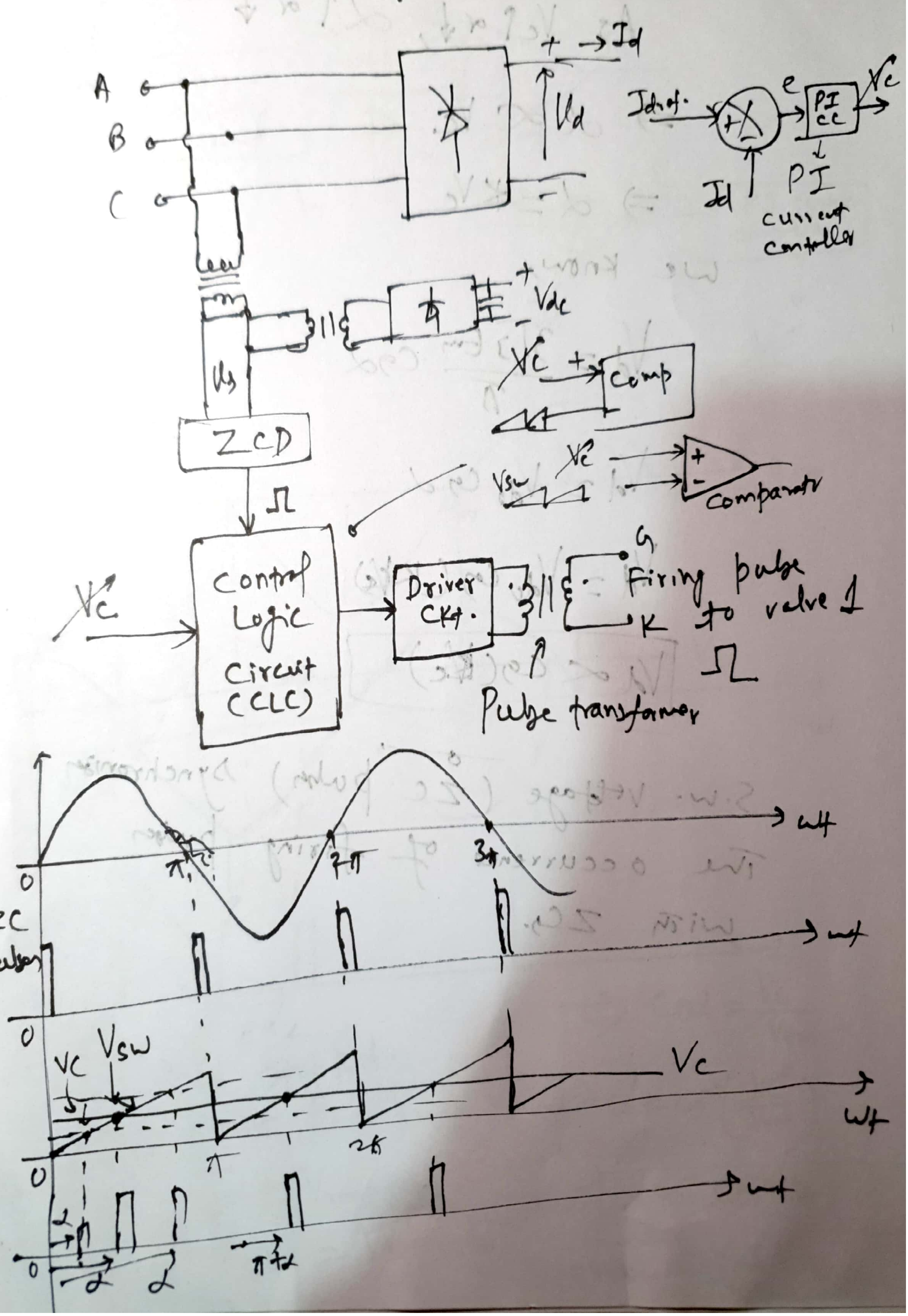


Six parallel delay ckts.

IPC

- Linear Firing Scheme
- Inverse cosine Firing Scheme.

a) Linear Firing Scheme:



As $V_c \uparrow$ or $\downarrow$, $\alpha \uparrow$ or $\downarrow$

$$\Rightarrow \alpha \propto V_c$$

$$\Rightarrow \alpha = K V_c$$

We know,

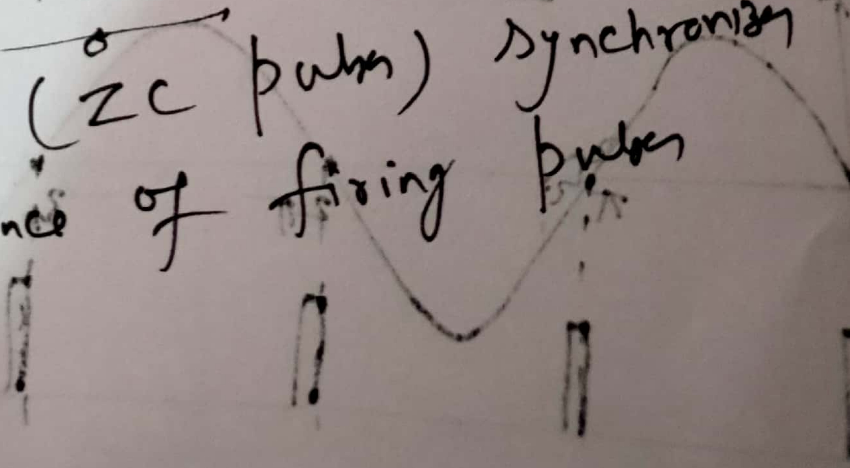
$$V_d = \frac{3\sqrt{3}\,E_m}{\pi} \cos\alpha$$

$$V_d = V_{d0} \cos\alpha$$

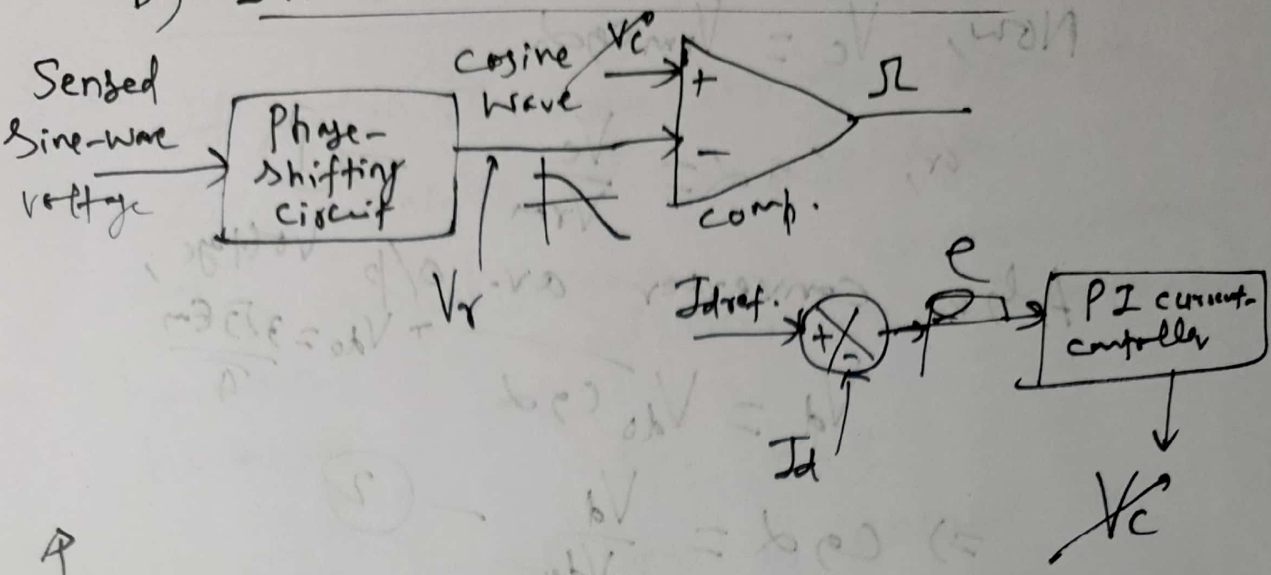
$$V_d = V_{d0} \cos(K V_c)$$

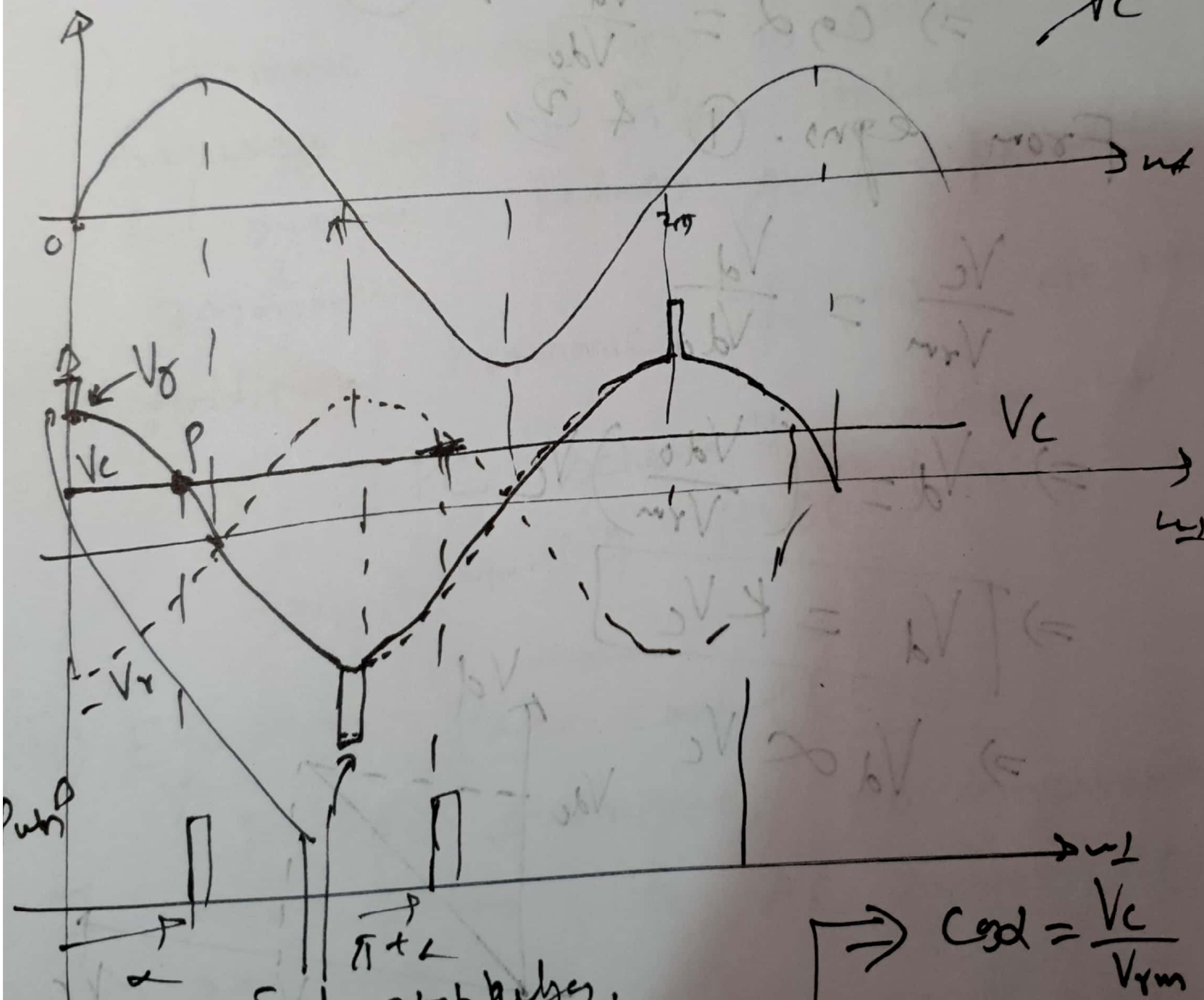
$$\boxed{V_d \propto \cos(V_c)}$$

S.W. voltage (ZC pulses) synchronizes the occurrence of firing pulses with ZCs.



b) Inverse Cosine Firing Scheme:





At point P, $V_r = V_c$

$$V_r = V_{rm} \cos\alpha$$

$$\therefore V_c = V_{rm} \cos\alpha$$

$$\Rightarrow \cos\alpha = \frac{V_c}{V_{rm}}$$

$$\therefore \alpha = \cos^{-1}\left(\frac{V_c}{V_{rm}}\right)$$

$$\Rightarrow \boxed{\alpha \propto \cos^{-1}(V_c)}$$

$\Rightarrow$ inverse cosine firing scheme.

Now, $V_c = V_{rm} \cos\alpha$

or, $\cos\alpha = \frac{V_c}{V_{rm}}$ — (1)

Also converter av. o/p voltage,

$V_d = V_{d0} \cos\alpha$ $\quad V_{d0} = \frac{3\sqrt{3}E_m}{\pi}$

$\Rightarrow \cos\alpha = \frac{V_d}{V_{d0}}$ — (2)

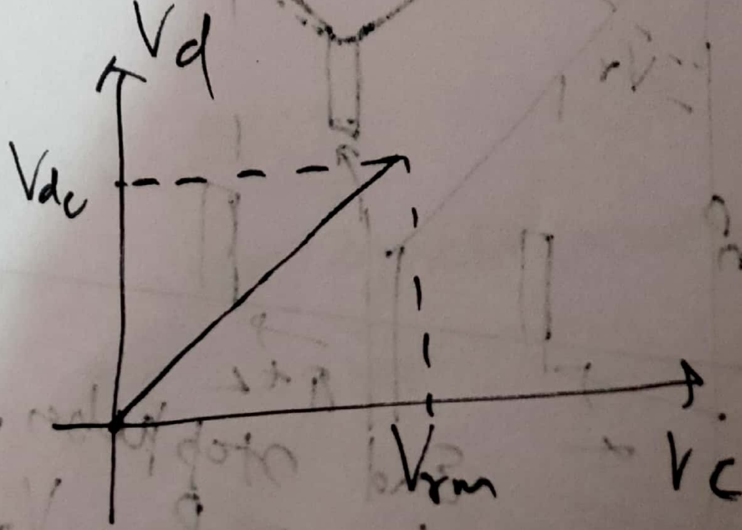
From eqns. (1) & (2)

$$\frac{V_c}{V_{rm}} = \frac{V_d}{V_{d0}}$$

$$\Rightarrow V_d = \left(\frac{V_{d0}}{V_{rm}}\right) V_c$$

$$\Rightarrow \boxed{V_d = K V_c}$$

$$\Rightarrow V_d \propto V_c$$



Drawbacks of IPC Scheme:

i) If, due to some voltage distortion, ZC shifts, α also changes. This will result in uncharacteristic harmonics in addition to characteristic harmonics.

$$h = np \pm 1$$

ii) Harmonic instability is caused at frequency where filter impedances & system impedances go in parallel resonance.

iii) Additional harmonic filters are required.

So, IPC scheme is seldom used for control of HVDC link.

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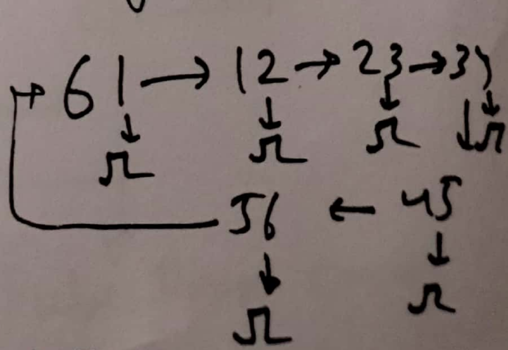
1) Equidistant Pulse control (EPC):

In EPC technique, no synchronization of control pulses with AC system (ZC) is required.

Let $\alpha_1 = 5^\circ$



$\therefore \alpha_2 = 60 + 5^\circ = 65^\circ$

$\alpha_3 = 65^\circ + 60 = 125^\circ \ldots$

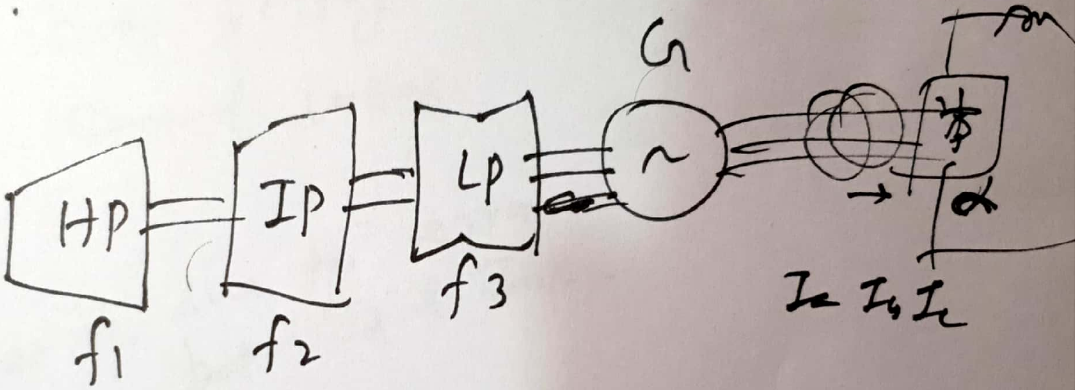
It produces pulses at equal intervals of $\frac{1}{fp}$.

$$\omega t = \frac{2\pi}{p}$$

$$\Rightarrow t = \frac{2\pi}{\omega p} = \frac{2\pi}{2\pi f \times p}$$

$$\Rightarrow \boxed{t = \frac{1}{fp}} \rightarrow \text{sec.}$$

Drawback:



$f_1, f_2, f_3 < 50\text{ Hz}$

Torsional oscillations

→ Turbine shafts → damaged.

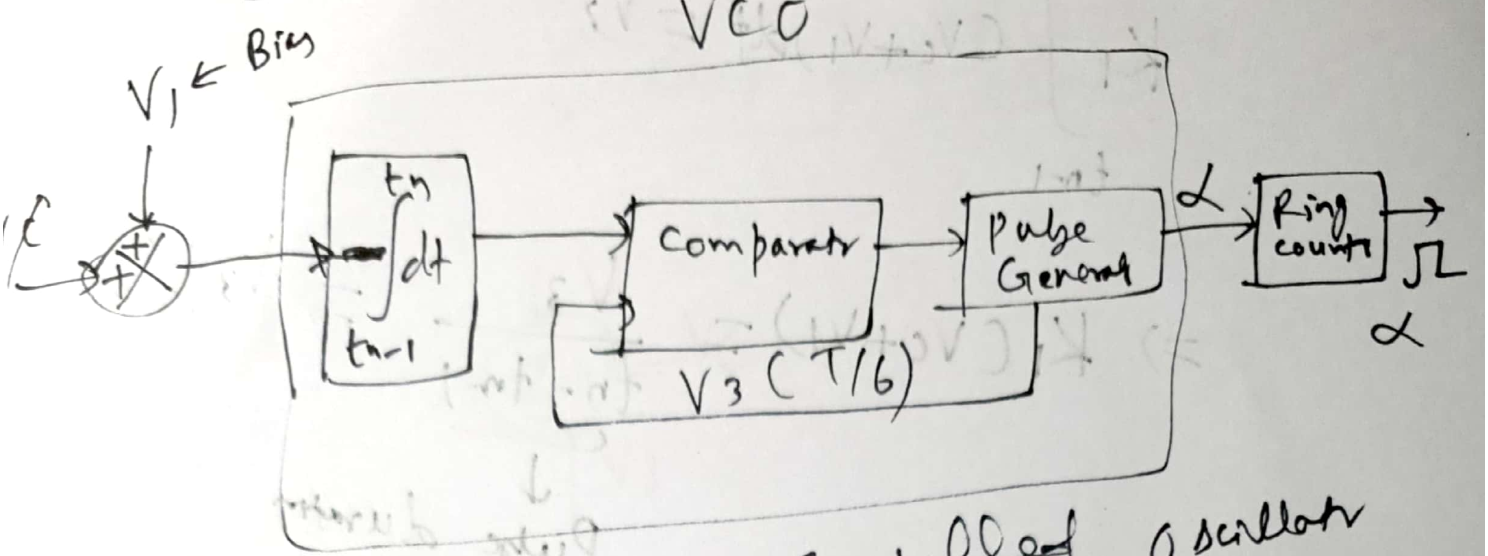
EPC scheme produces −ive damping contributing to torsional oscillations.

EPC Scheme

→ Pulse Frequency control (PFC)

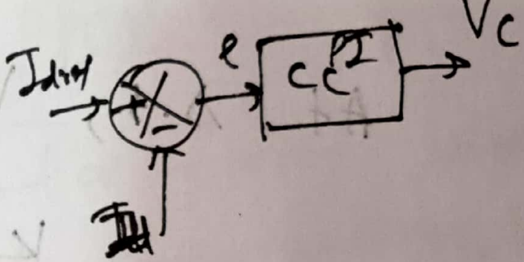
→ Pulse Phase control (PPC)

PFC scheme:

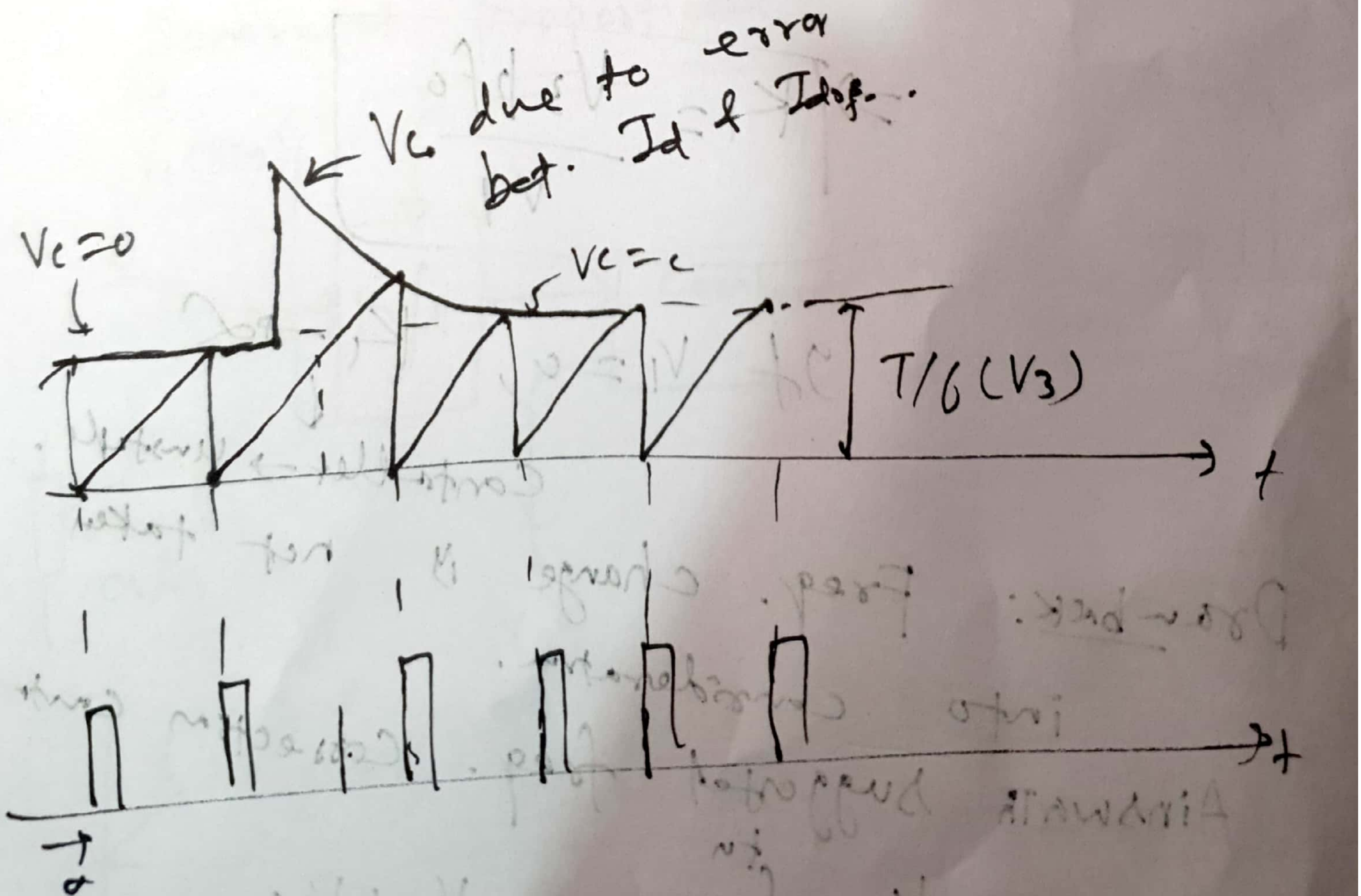


VCO: Voltage-Controlled Oscillator

V_1: Bias voltage



V_c: Control voltage



$$K_1 \int_{t_{n-1}}^{t_n} (V_c + V_1)\,dt = V_3$$

$$\Rightarrow K_1(V_c + V_1) = \frac{V_3}{\underbrace{t_n - t_{n-1}}_{\text{Pulse duration}}} = V_3\, p f_0$$

At s.s., $V_c = 0$

$$\therefore K_1 V_1 = V_3\, p f_0$$

$$\Rightarrow \boxed{K_1 = \frac{V_3\, p f_0}{V_1}}$$

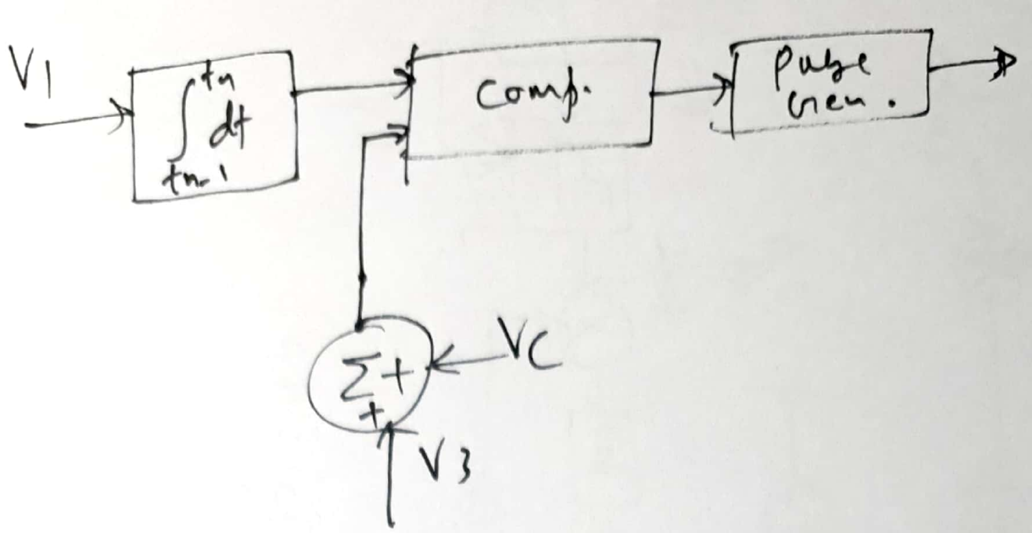
If $V_1 = 0$, $K_1 \to \infty$
Controller → unstable.

<u>Drawback</u>: Freq. change is not taken into consideration.

Ainsworth suggested freq. correction control,

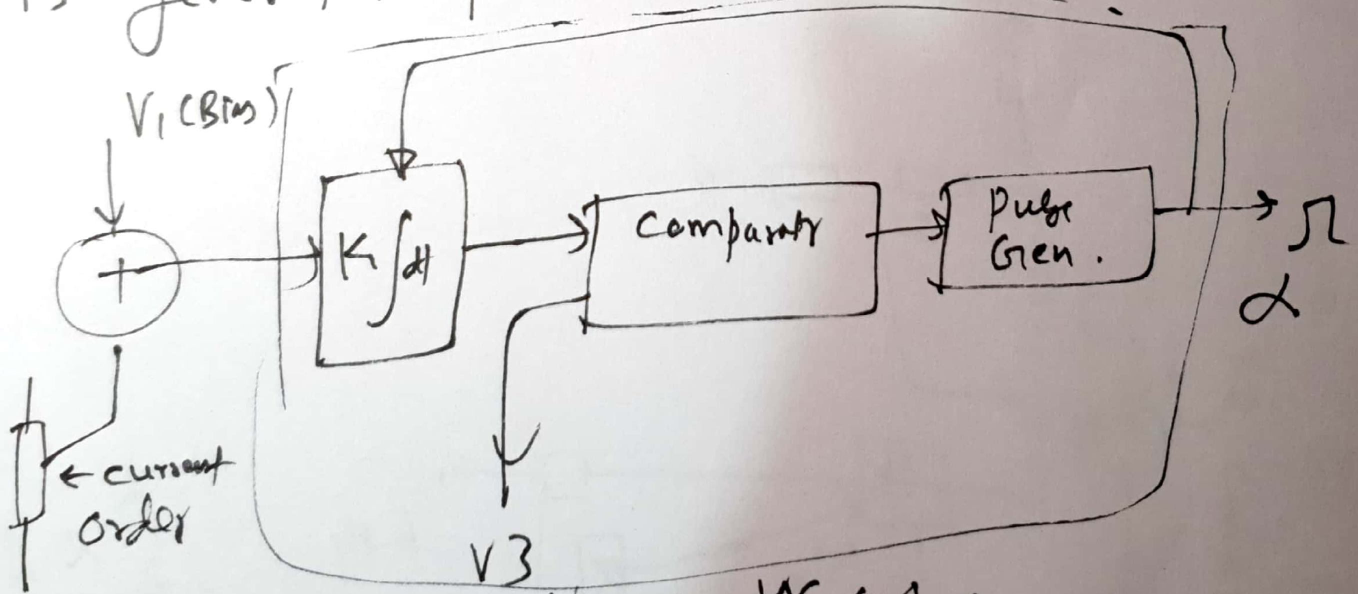
$$K_1 \int_{t_{n-1}}^{t_n} V_L\,dt = V_3 + V_c$$

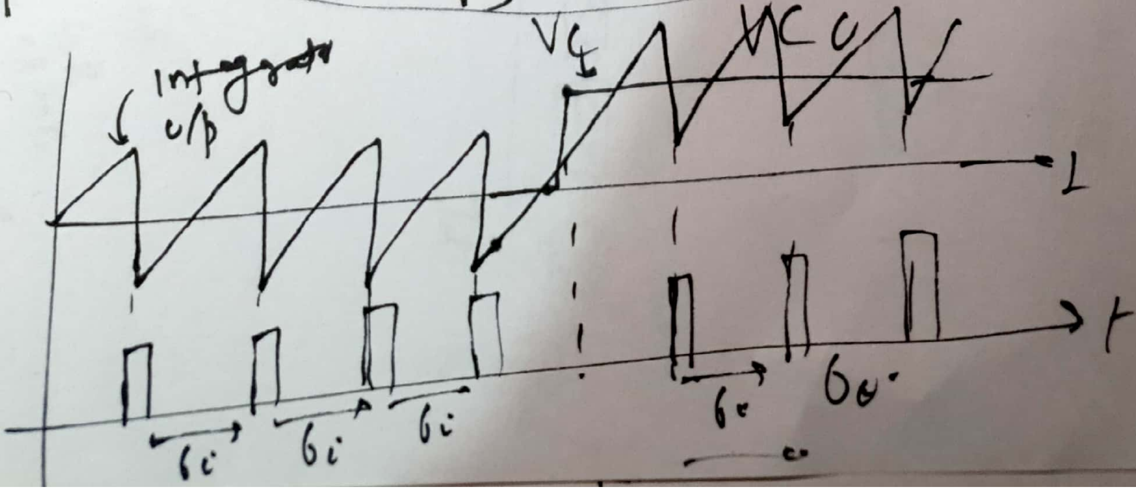
$$\Rightarrow K_1 = \frac{V_3\, p f_0}{V_1}$$



b) Pulse Phase control (PPC):

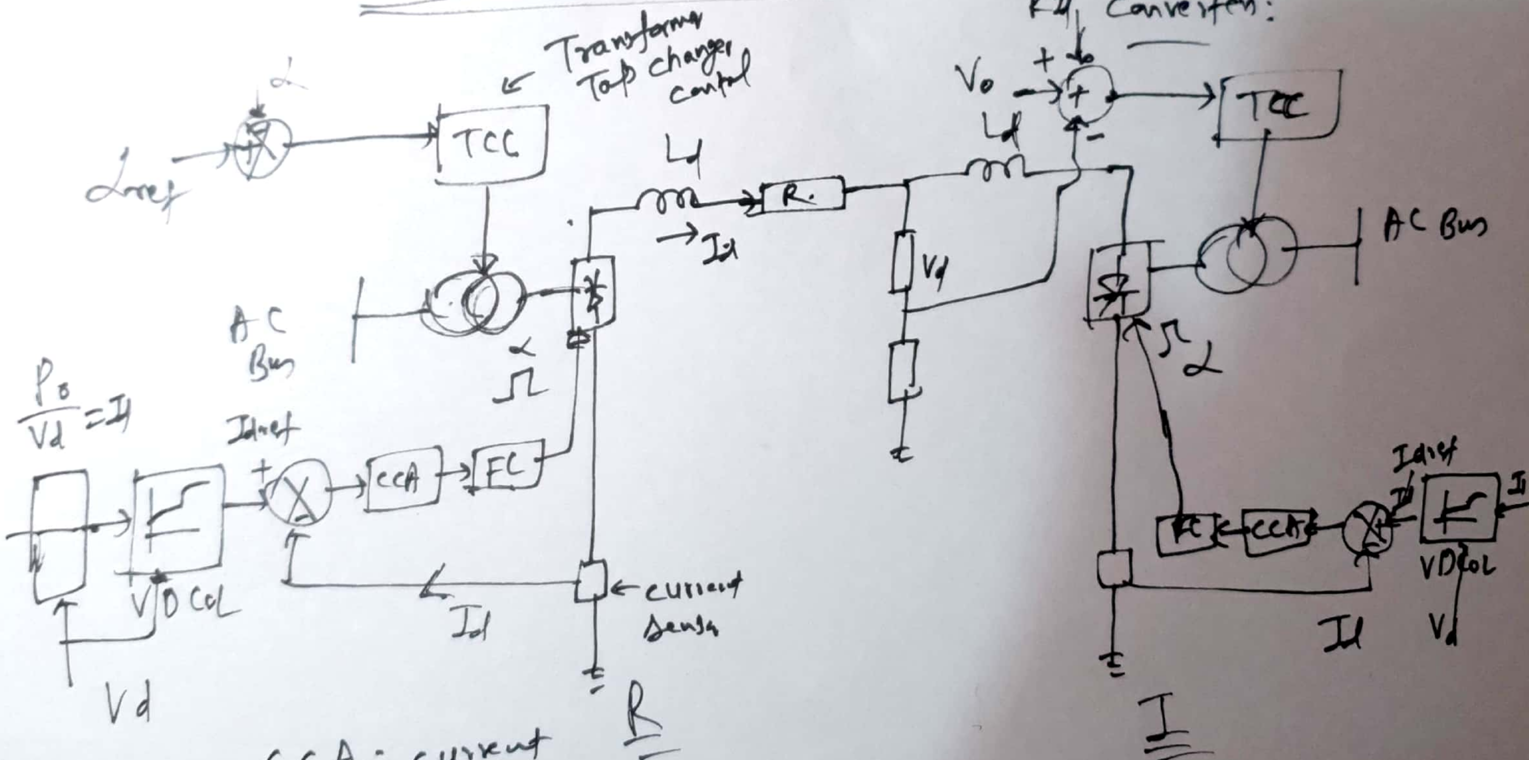
A train of control or firing pulses is generated proportional to control voltage, Vc.





(20)

Complete Basic Control Scheme of HVDC Converter:



CCA : current control Amplifier.

FC : Firing Ckt.

395 MB
3.25 GB
317.98 MB
8 62.43 MB