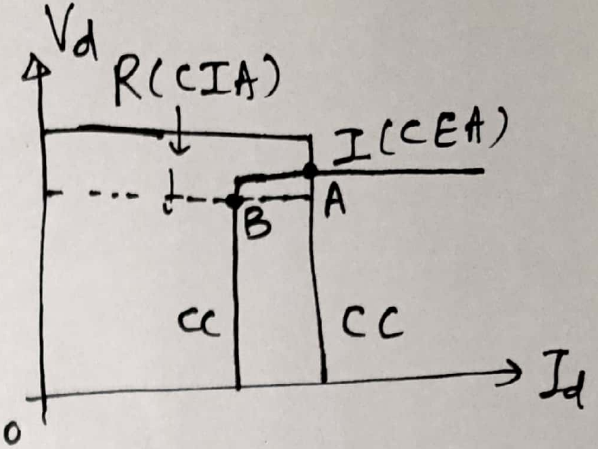
Control characteristics:



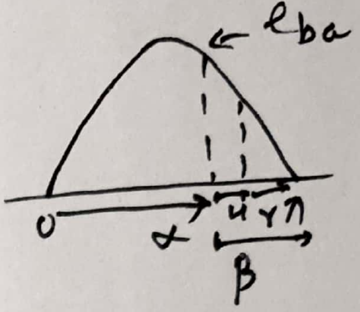
γ - control (inverter)

⇕

$\gamma = \gamma_{min.}$ (constant)

$\gamma_{ref.}$ 15°

γ_{actual} ↓ 10° ⇒ 15°



- γ - control is also not 100% ideal.
- There is a substantial amount of risk of commutation failure.

$\beta = \gamma + u$

$$I_d = I_{s3}(\cos\gamma - \cos\beta)$$

$$I_d = \frac{\sqrt{3}E_m}{2\omega L}(\cos\gamma - \cos\beta)$$

Let inverter side AC voltage fall.

$I_d \uparrow$

$$I_d = \frac{\sqrt{3}E_m}{2\omega L}(\cos\gamma - \cos\beta)$$

γ is fixed at γ_{ref}.

∴ For given γ, I_d, E_m, ω & L, β is calculated.

ii) The above computation (β-calculation) is based on reduction of AC-side voltage of inverter due to 3-ϕ symmetrical fault.

For asymmetrical faults (L-G, L-L faults), u increases and β is wrongly computed by the controller; hence resulting in commutation failure

ii) If rate of rise of Id is small, it will be taken care of by controller. But if dI_d/dt is fast, it will result in wrong calculation of β and hence commutation failure.

iii) Commutation failure may occur when voltage reduction on inverter AC side takes place just after the firing of a valve. But the probability of this is low as compared to (i) & (ii) above.

Therefore, it is not sufficient to compute Em and Id only; following is to be considered:

a) Amplitude of commutation voltage

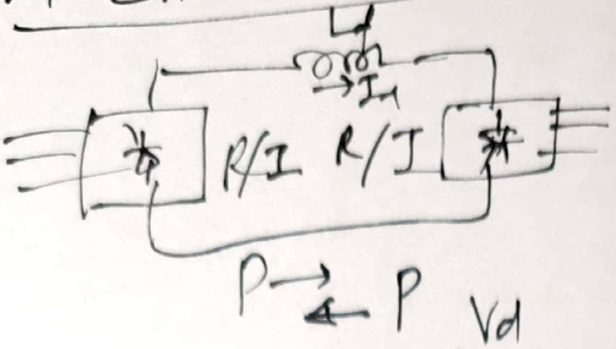
b) Phase of " "

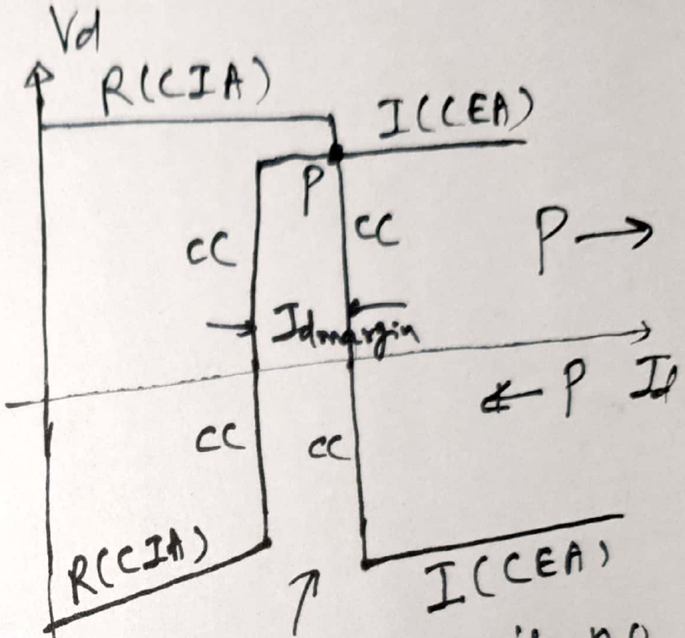
c) Magnitude of Id

d) Rate of change of DC line current (dI_d/dt)

$$\gamma = \underline{\underline{\gamma_{ref}}}$$

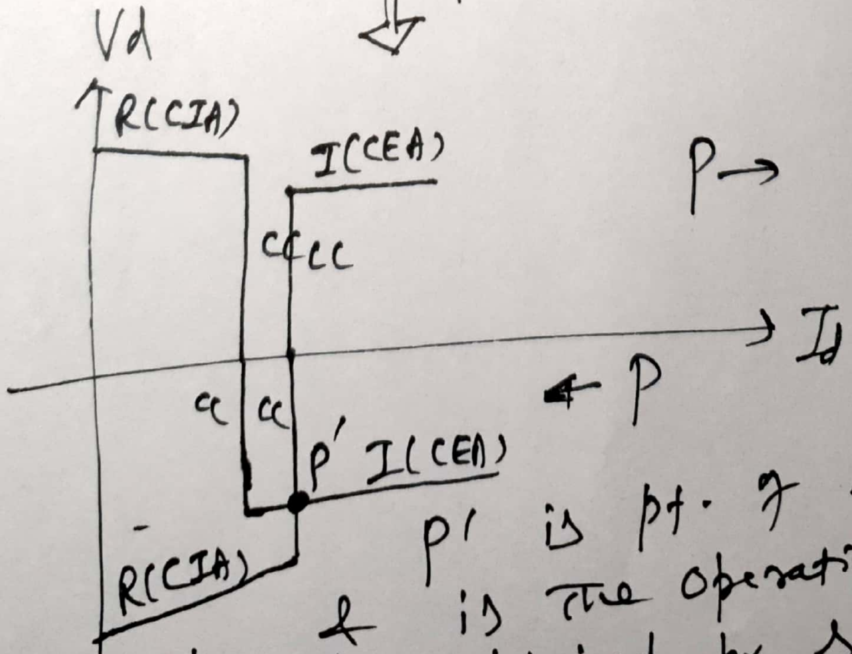
Control Characteristics for Power-Reversal:





Since there is no pt. of intersection, no operating pt.

⇩

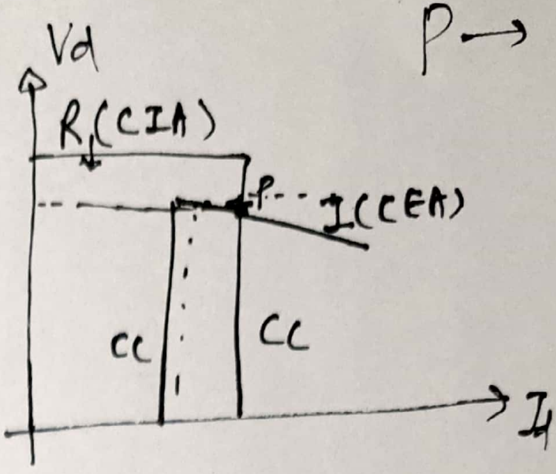


P′ is pt. of intersection & is the operating pt.

Thus opern. pt. is obtained by swapping the cc characts. of R & I for reverse power flow.

Corrections in Control characteristics:

Due to fault, the inverter-side AC voltage reduces.

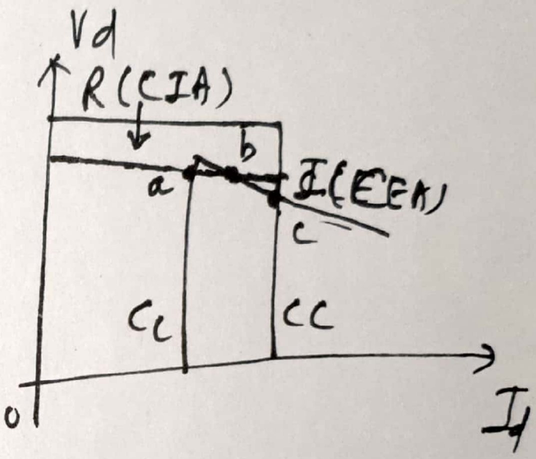


$I_d\uparrow \rightarrow u\uparrow$

$\rightarrow R_{ci}\uparrow$

$\underline{\underline{V_{di}}} = V_{doi}\cos\gamma - \underline{\underline{\overset{\uparrow}{R_{ci}}}} I_d$

Due to drooping nature of inverter charact., There are now Three pts. of intersection bet. R & I characts. (a, b & c).



⇒ Controller hunts for stable operating point & it will keep on hunting.

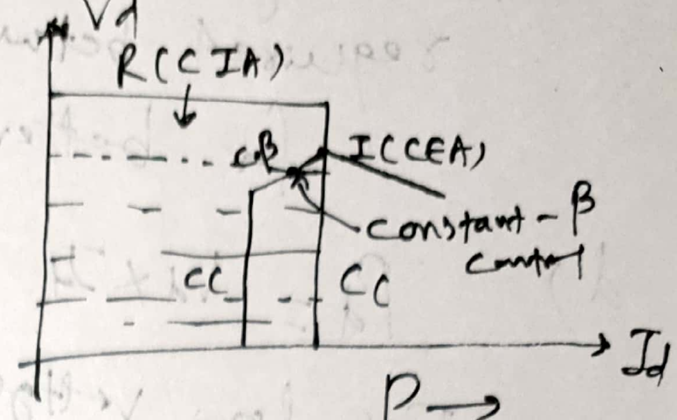
⇒ Controller & HVDC Link → unstable.

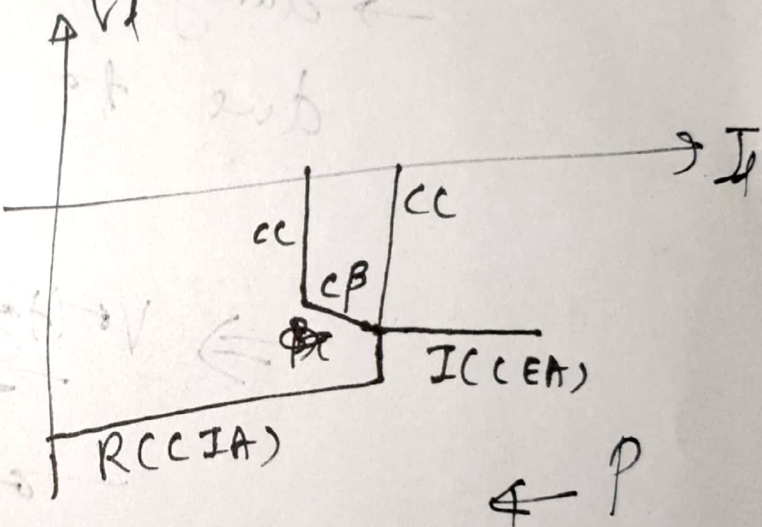
⇒ To address this issue, inverter charact. is modified either with Constant voltage control or constant-β control.

↓

worsens pf

Modified control characts:





Other considerations:

- Always voltage or current controllers are used instead of DC power controls because:

a) Line resistance, $R_l \downarrow$ → Smaller damping factor → Huge power oscillations → unstable operm.

b) $P_d \nearrow = V_d \nearrow \cdot I_d \nearrow$ → controller becomes complex & loses flexibility

c) A strong communication link is required between both sides for better control.

d) $P_d = V_d \times I_d$

For low voltage, $\underline{P_d} = \downarrow V_d \times I_d \uparrow\uparrow$

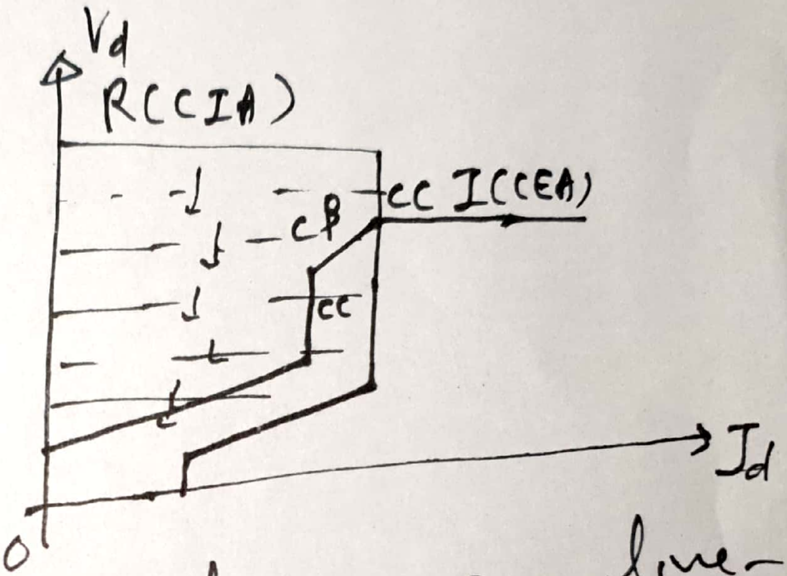
→ damage of valves (converters) due to high I_d.

⇒ Voltage-control

I_d →

Incorporating VDCOL in control characts:

VDCOL : Voltage-Dependent current-order Limit



Controller puts some limit on line-current to avoid damage.

⇒ VDCOL

* * *

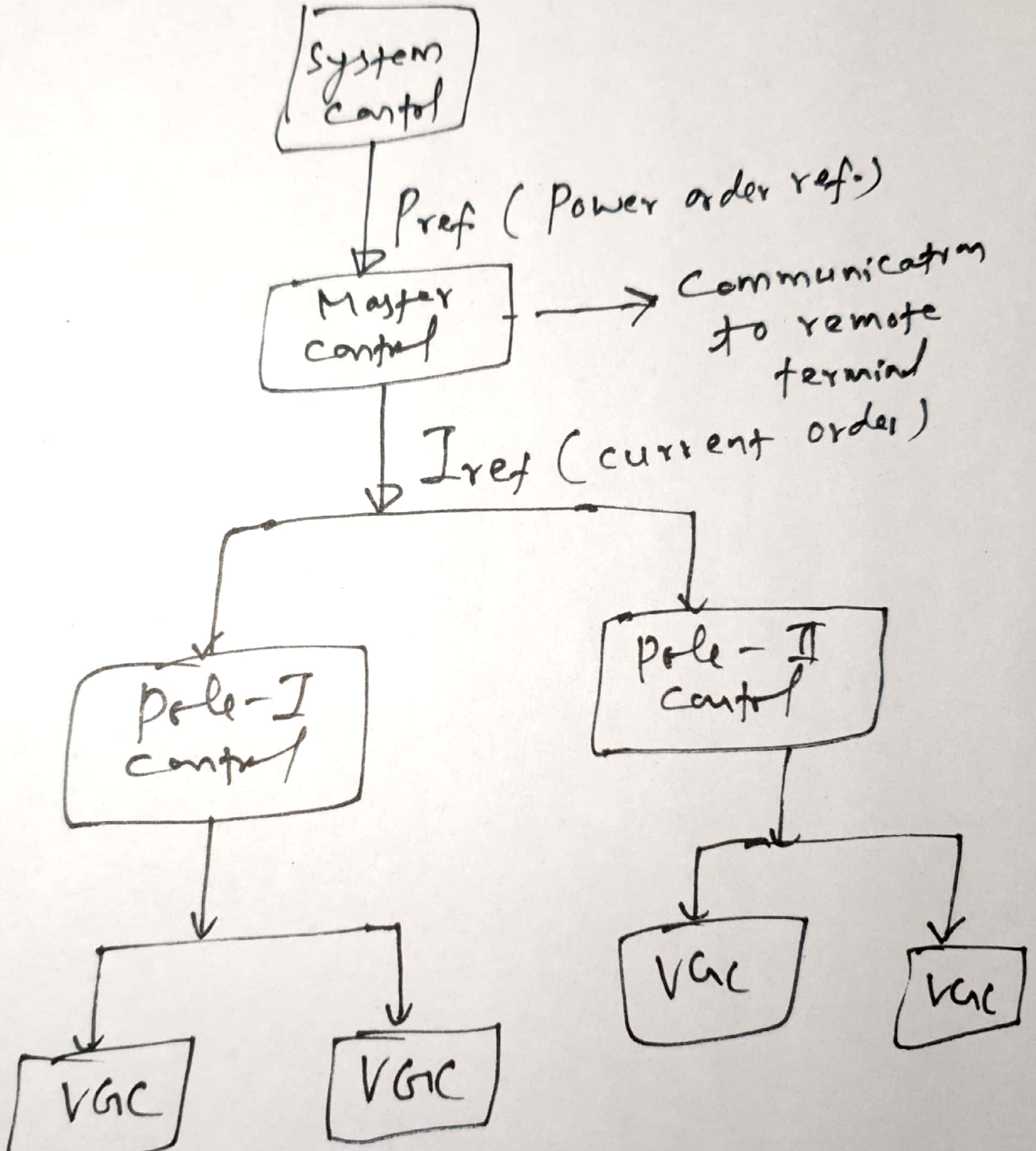
Final control characts:

R: CIA, CC, VDCOL

I: CEA, Cβ, CC, VDCOL

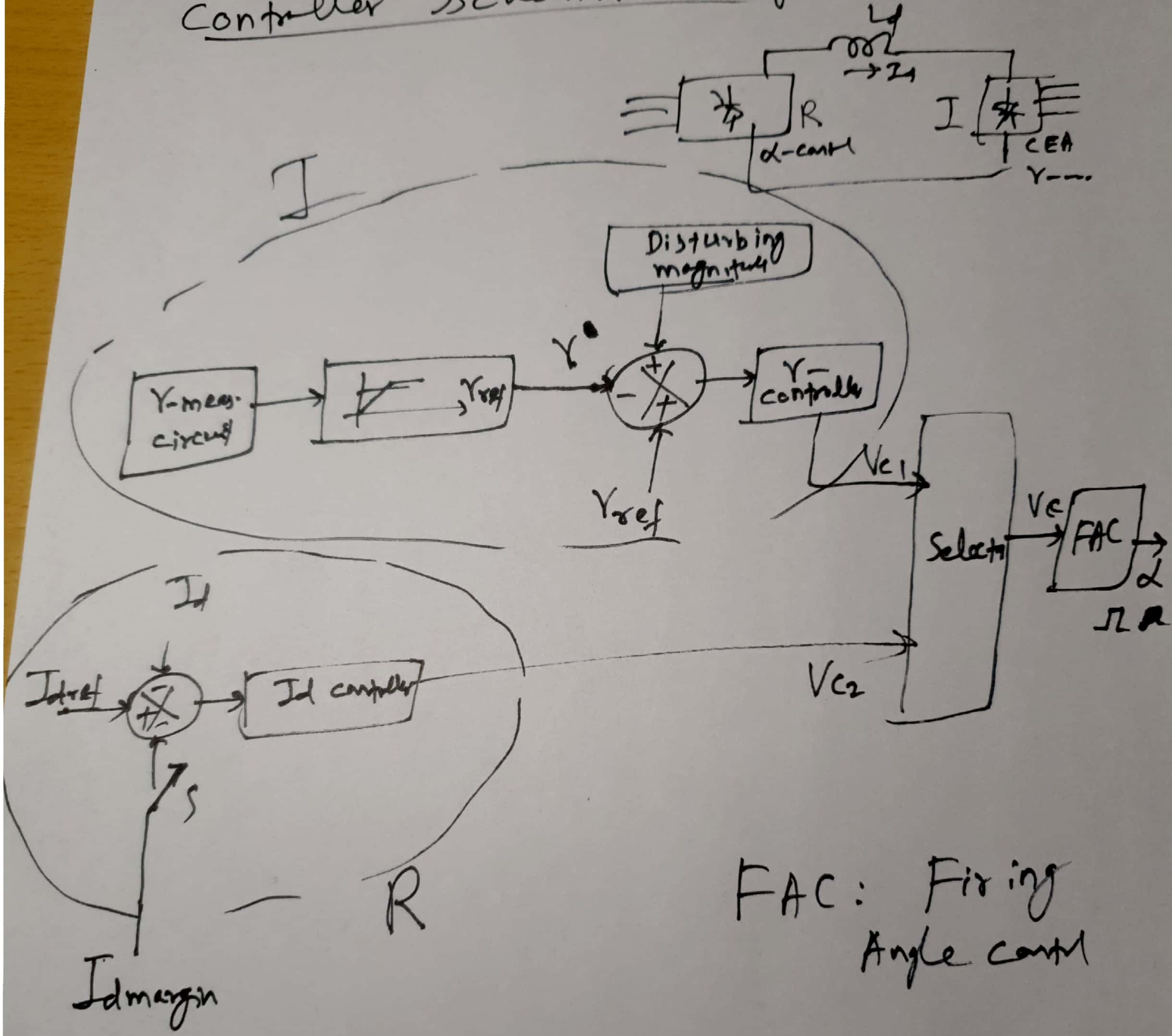
* * *

Controller Design Philosophy (Heirarchy):



VGC: Valve Group Control

Controller schematic diagram:



FAC: Firing Angle control