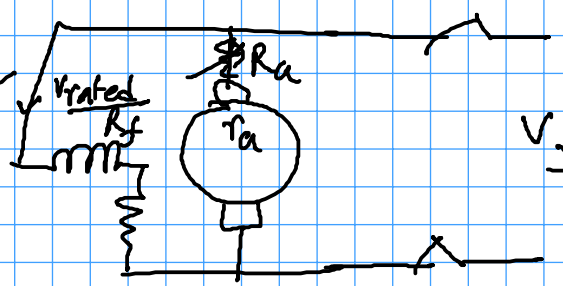
Lec 79

Motor :
- Starting ✓
- Speed control ✓
- Braking ✓



Vrated

Vrated / ra

Shunt motor starting :

3-point starter

Connect Ra (ext) in the armature at the time of starting

Vrated / (ra + Ra)

& as motor picks up speed gradually cut this Ra to 0

V = 200 V

ra = 0.5 Ω

Ia rated = 20 A

$$\therefore I_{a\,starting} = \frac{200}{0.5 + R_a} = 20$$

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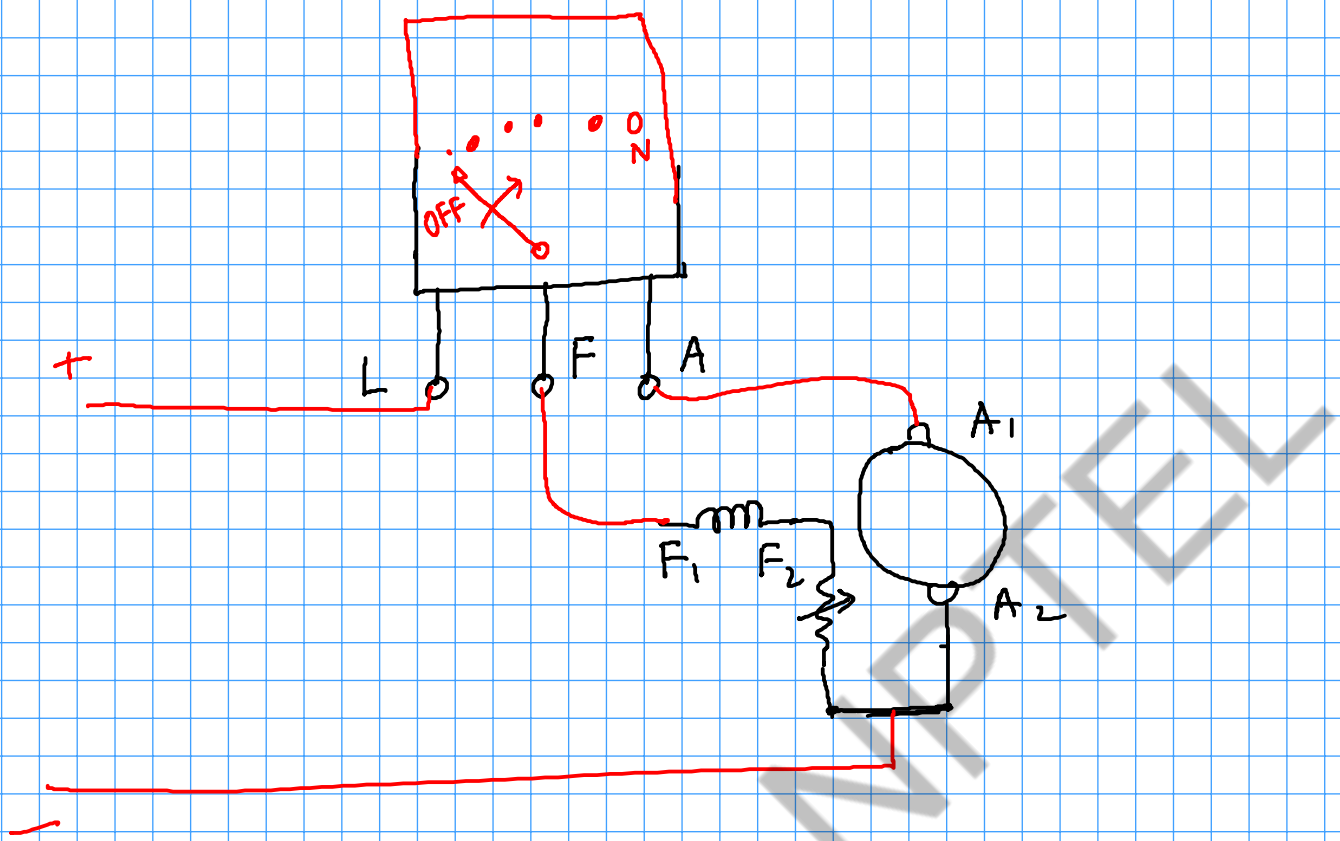
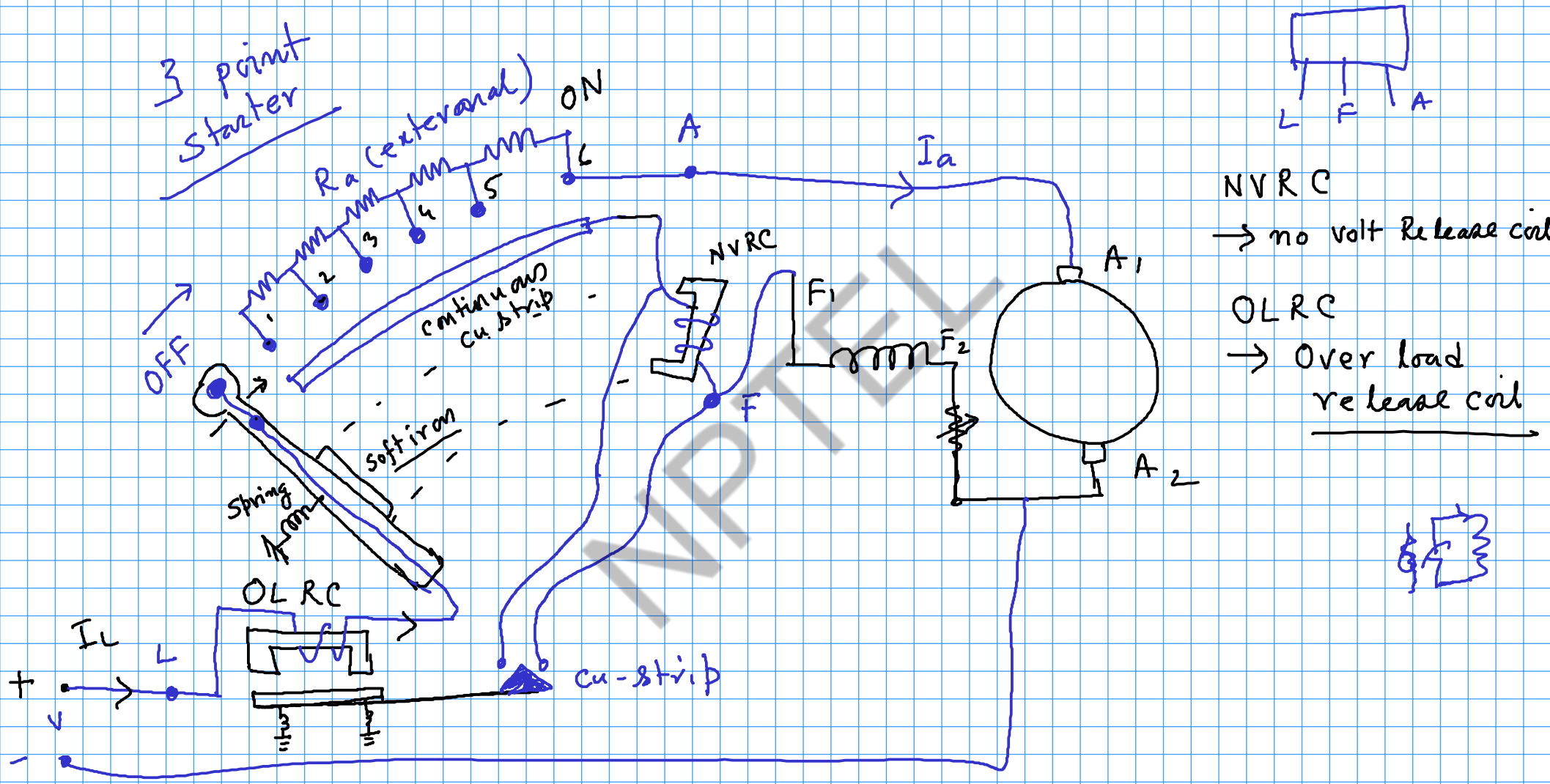

OFF
ON
+
L
F
A
A1
F1
F2
A2
−


3 point Starter
Ra (external)
ON
L
A
Ia
1
2
3
4
5
OFF
continuous Cu strip
NVRC
F1
F2
A1
A2
F
Soft iron
Spring
OLRC
IL
L
+
V
-
Cu-strip
L
F
A
NVRC
→ no volt Release coil
OLRC
→ Over load release coil
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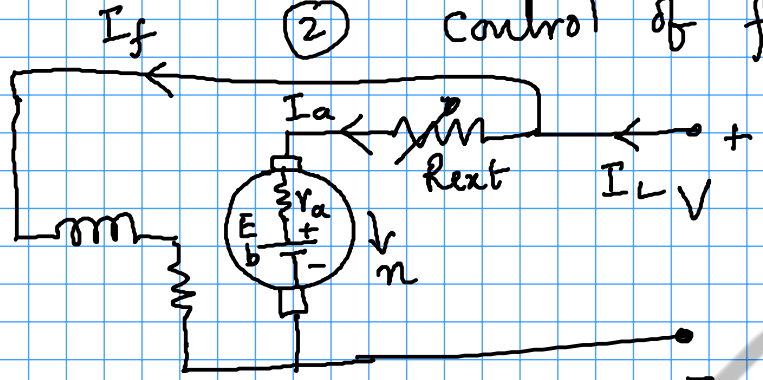
Speed control of D.C shunt/Separately excited motor

Lec-80

$I_L = I_a + I_f$

① Control of armature voltage
- Armature resistance control (R_{ext})
- Armature voltage control

② Control of field current



$I_a = \frac{V - E_b}{r_a}$ when $R_{ext} = 0$

$T_{L_{rated}} = T_{e_{rated}} = K\phi I_{a_{rated}}$

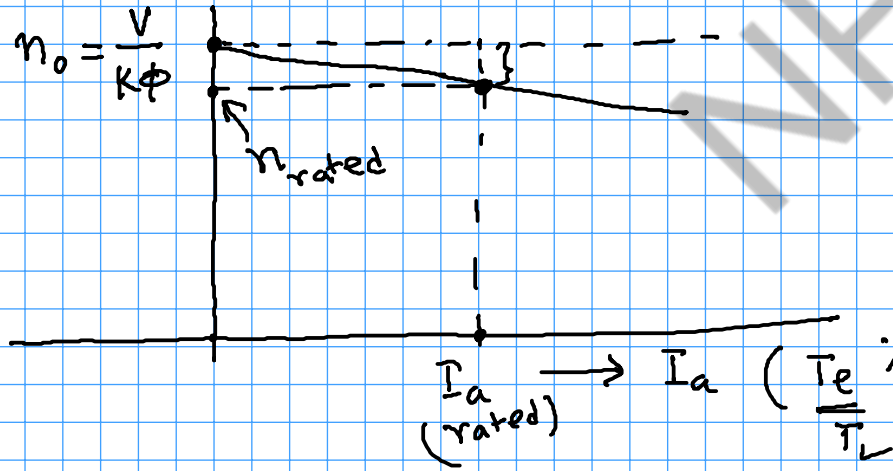
Armature KVL equn.

$V = I_a (r_a + R_{ext}) + E_b$

$V = I_a r_a + K\phi n_r$

$$n_r = \underset{n_0}{\left(\frac{V}{K\phi}\right)} - \frac{r_a}{K\phi} I_a$$

$$T_e = K_T \phi I_a = T_L = \text{constant}$$



$I_a \rightarrow I_a$ ($\frac{T_e}{T_L}$ if ϕ is constant)

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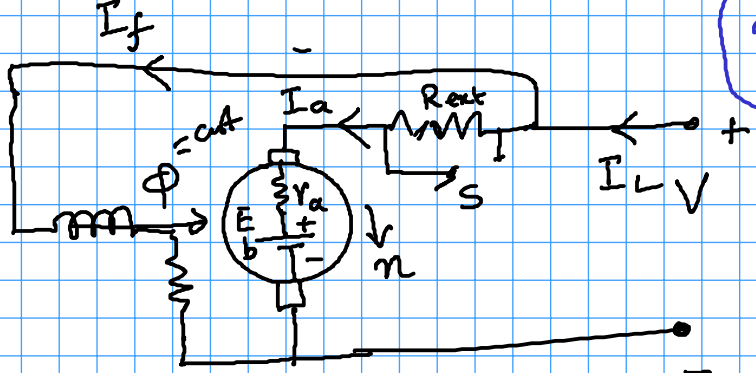
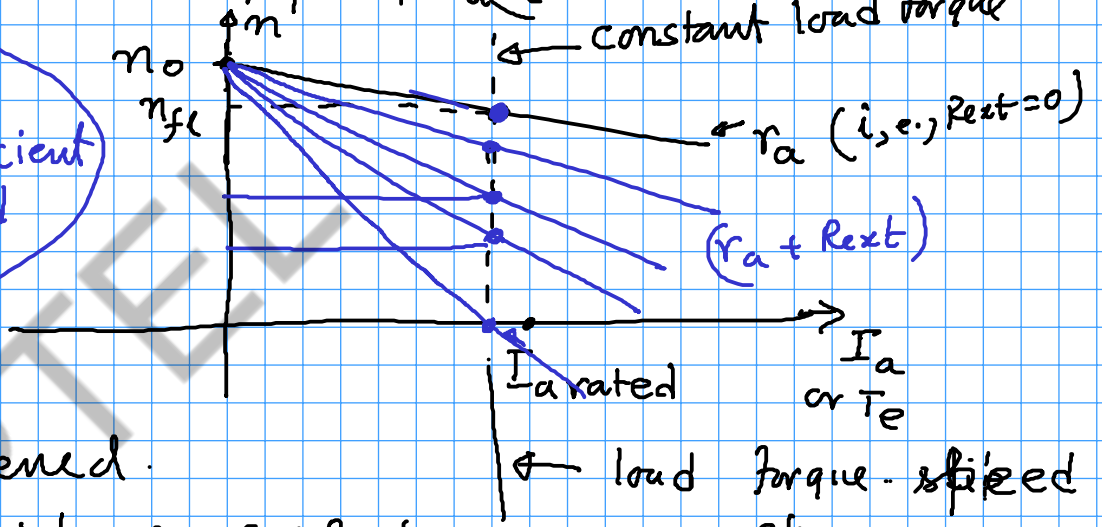
Let Load torque (T_L) is constant

$$n = \frac{V}{K\phi} - \frac{(r_a + R_{ext})}{K\phi} I_a$$

$$V = K\phi n + I_a(r_a + R_{ext})$$



not an efficient method



Suppose at $t=0$, s is opened.

so that Armature resistance $r_a + R_{ext}$

at $t=0^+$ Speed n_{fl}

V is constant

$$I_a(0^+) = \frac{V - E_b(0^+)}{r_a + R_{ext}} = \frac{V - E_b(0^-)}{r_a + R_{ext}}$$

(Constant) T_L ∝ ◯ ↓n → T_e

at $t(0^+)$ $T_e < T_L$

$I_a(0^+)$ ↓

∴ Motor starts decelerating n ↓

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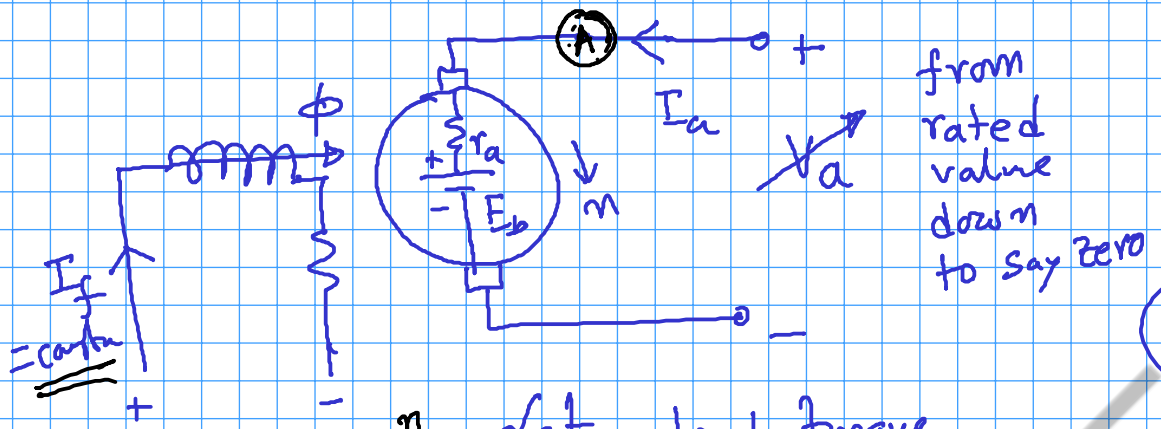
Armature voltage control

Lec - 81



from rated value down to say zero

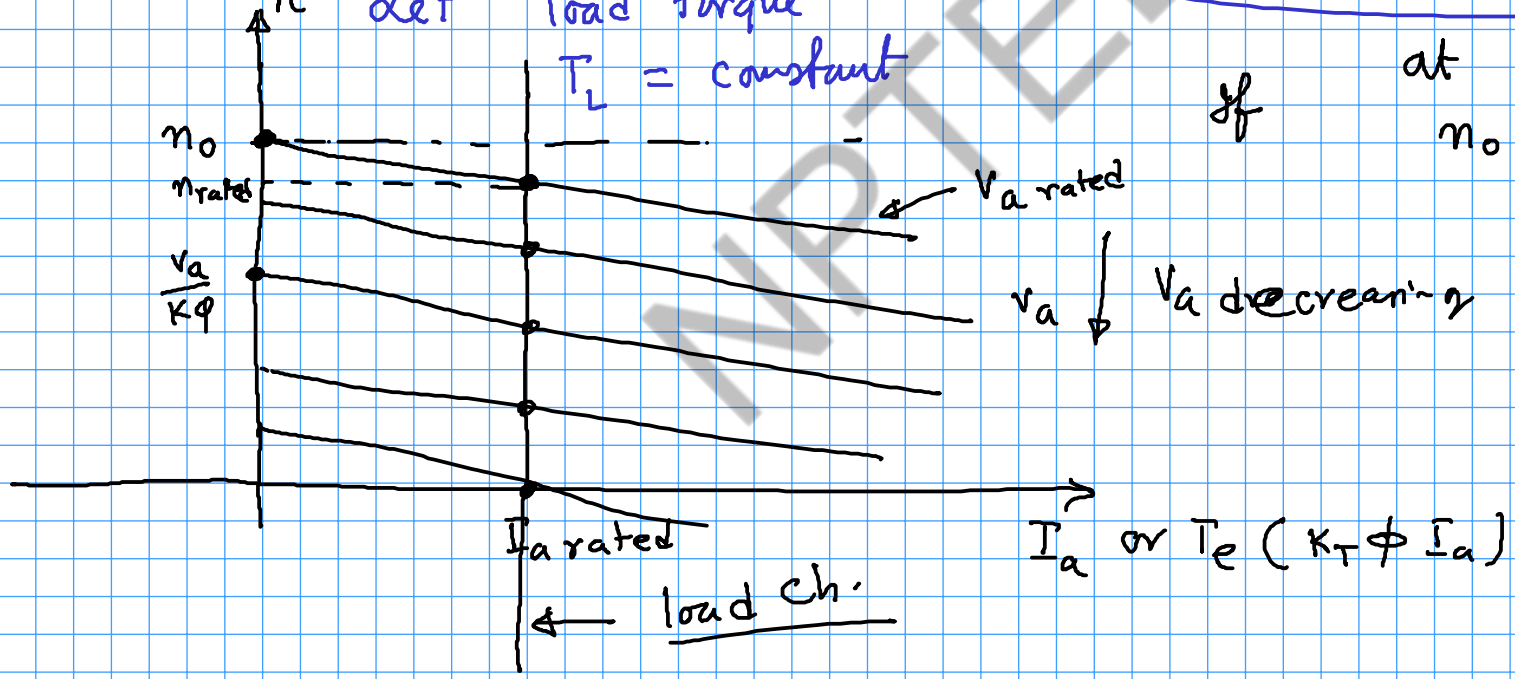
$$V_a = K\phi n + I_a r_a$$

$$n = \frac{V_{a\,rated}}{K\phi} - \frac{r_a}{K\phi} I_a$$

$$T_a = \frac{V_a - r_a I_a}{K\phi}$$

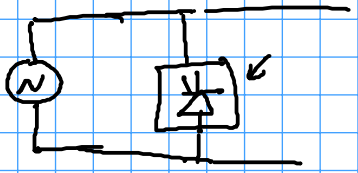
$$I_a = \frac{V - E_b}{r_a}$$

Let load torque T_L = constant



If at no load $I_a = 0$

$$n_0 = \frac{V_{a\,rated}}{K\phi}$$



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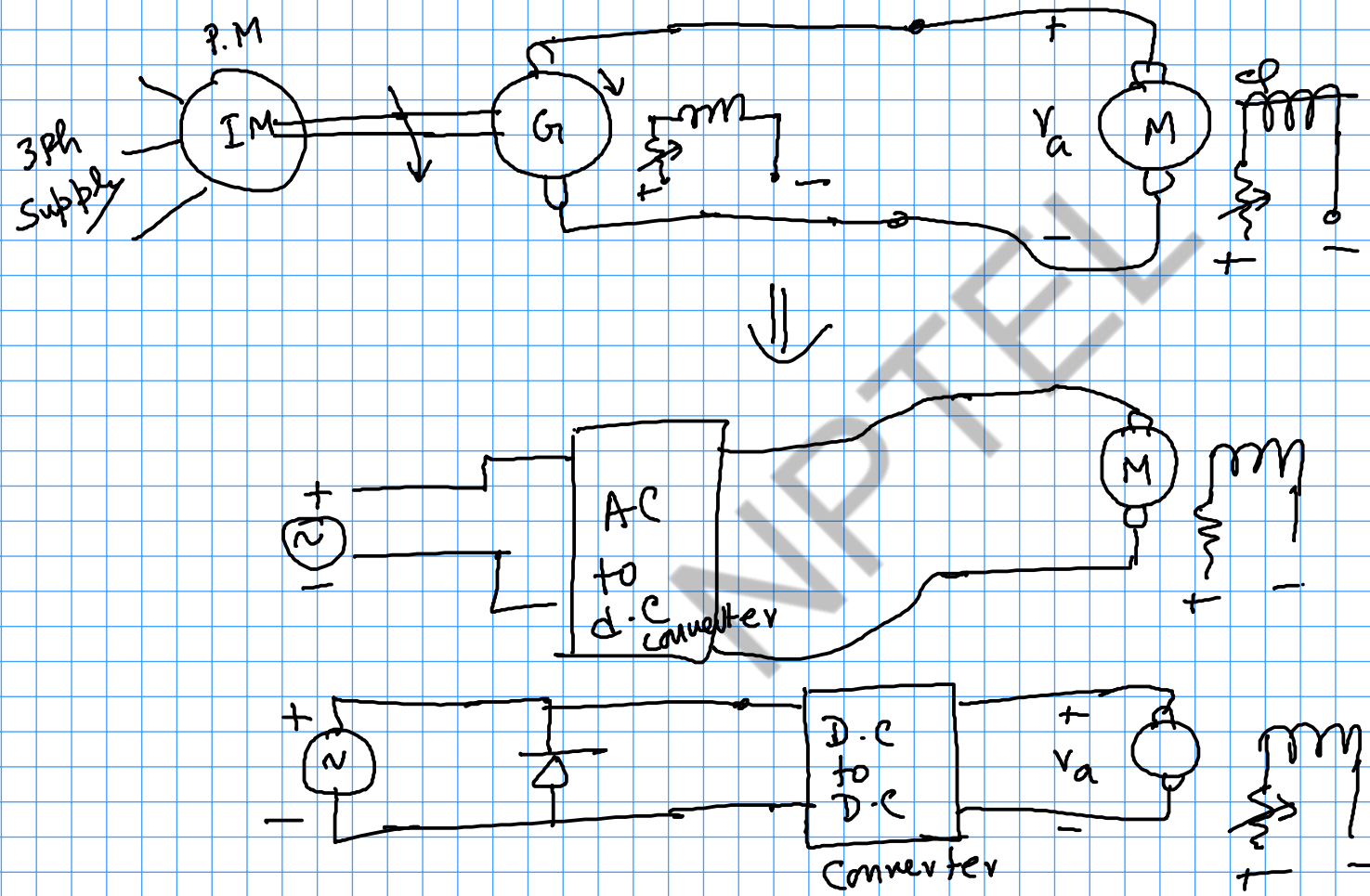

- Armature Resistance control
- Armature voltage control

I_a remains constant at constant load torque

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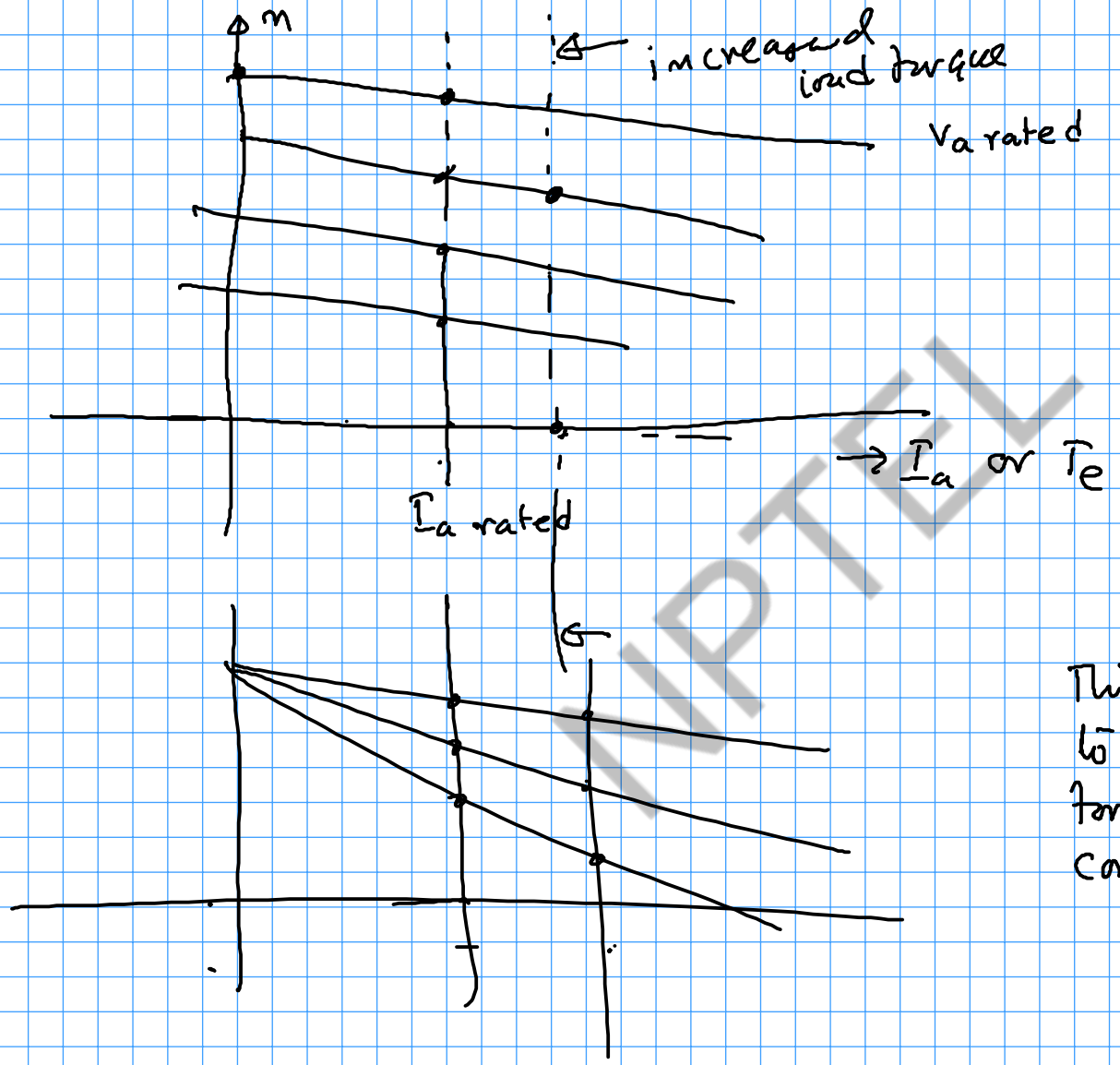

Suppose I reduce the armature applied voltage along with load torque demand is increased.

$T_e = K \phi I_a$

This method is adopted to supply a load whose torque demands remains constant

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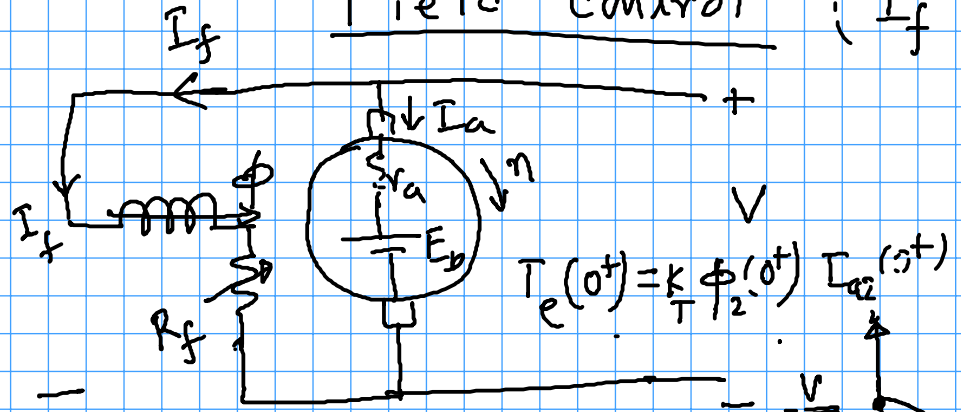
Field control (I_f control)

$k\phi n$

$T_e = K_T \phi_1 I_{a1} = T_L$

$V = I_{a1} r_a + K\phi_1 n_1$

$$n_1 = \frac{V}{K\phi_1} - \frac{r_a}{K\phi_1} I_{a1}$$



$T_e(0^+) = K_T \phi_2(0^+) I_{a2}(0^+)$

Suppose I_f is reduced to I_{f2} from I_{f1} at $t = 0$

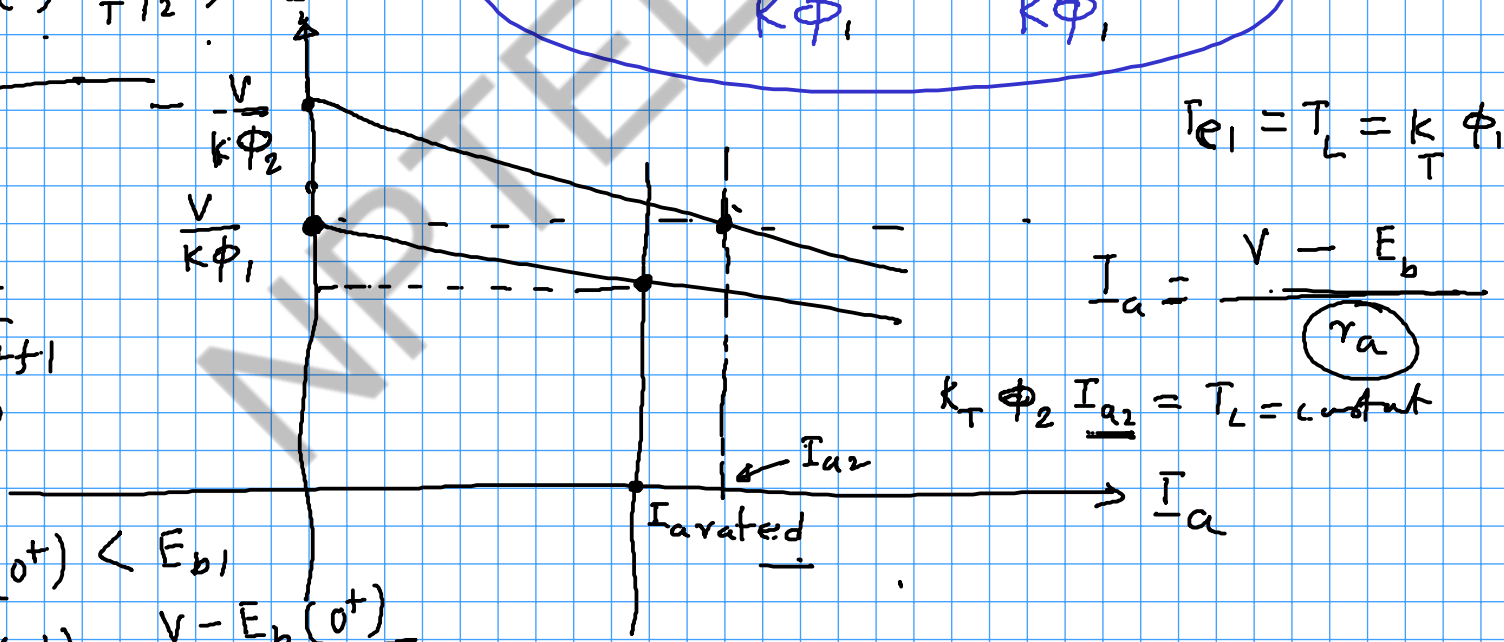
$I_{f1} \rightarrow \phi_1$

$I_{f2} \rightarrow \phi_2$

at $t = 0^+$

$E_b(0^+) < E_{b1}$

$$I_a(0^+) = \frac{V - E_b(0^+)}{r_a}$$



$T_{e1} = T_L = K_T \phi_1 I_{a1}$

$$I_a = \frac{V - E_b}{r_a}$$

$K_T \phi_2 I_{a2} = T_L = \text{constant}$

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field control

$$T_{e1} = K_T \Phi_1 I_{a1}$$

$$= K_T \Phi_2 I_{a2}$$

we reduce the flux Φ_1 to Φ_2.

If T_L = constant

$$K_1 \Phi_1 I_{a1} = K_T \Phi_2 I_{a2}$$

(I_{a1}: rated)

$$I_{a2} = \frac{\Phi_1}{\Phi_2} I_{a1\,rated}$$

$\Phi_2 < \Phi_1$

$I_{a2} > I_{a\,rated}$.

$\Phi_1 \; I_{a\,rated}$

$\Phi_2 \; I_a$

is not suitable to drive constant mechanical load.

But it is suitable for constant power load

Power $= T_L \times \omega_r$ = const

or $T_L \propto \frac{\text{const.}}{n_r}$

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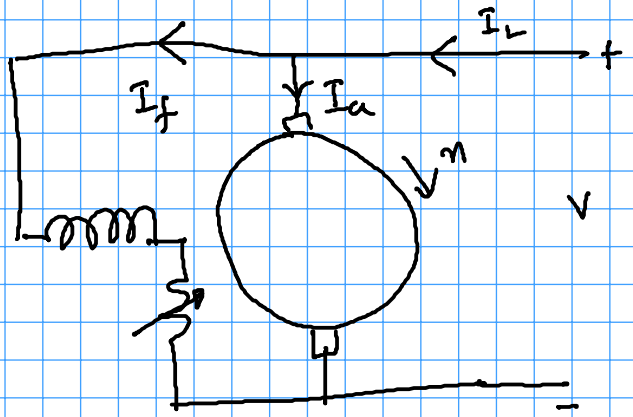
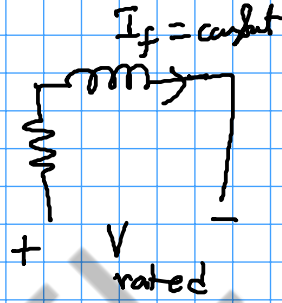


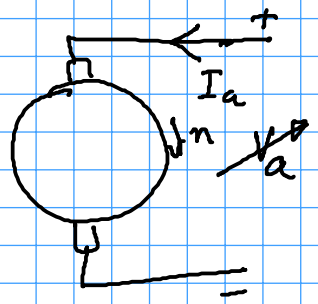
field control to is adopted above rated

Suitable for constant Power load

i.e., $T_L \propto \frac{1}{\text{Speed}}$

$T_e = T_L = K\phi I_a$





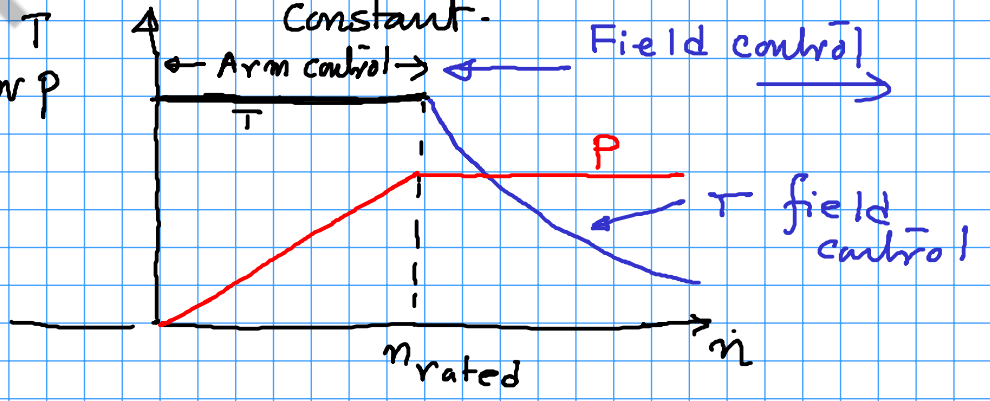
Lec 83

$T_L \simeq T_e$

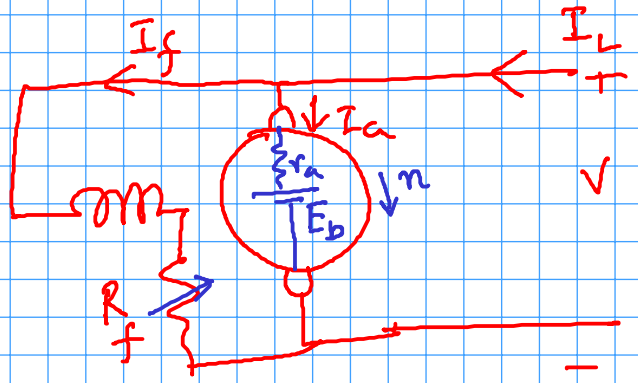
$\simeq K\phi I_a$

Armature voltage control

Suitable for constant load torque as I_a will remain constant.



NPTEL



I_{a1}, I_{f1}, n_1

$$E_{b1} = K I_{f1} n_1 = V - I_{a1} r_a \quad \text{— (1)} \qquad I_{f1} = \frac{V}{R_{f1}}$$

$$T_{e1} = T_{L1} = K_T I_{f1} I_{a1} \quad \text{— (2)}$$

Second case $R_{f1} \xrightarrow{\text{increased}} R_{f2}$

$I_{f1} \longrightarrow I_{f2}$ $(I_{f2} < I_{f1})$

$$E_{b2} = K I_{f2} n_2 = V - I_{a2} r_a \quad \text{— (3)}$$

I_{a2}, n_2

$$T_{e2} = T_{L2} = K_T I_{f2} I_{a2} \quad \text{— (4)}$$

$$\frac{T_{e2}}{T_{e1}} = \frac{K_T I_{f2} I_{a2}}{K_T I_{f1} I_{a1}} = \frac{T_{L2}}{T_{L1}} = 1 \quad \text{for constant load torque}$$

$$= \frac{n_1}{n_2} \quad \text{if power is constant}$$

$$\frac{E_{b2}}{E_{b1}} = \frac{V - I_{a2} r_a}{V - I_{a1} r_a} = \frac{I_{f2} n_2}{I_{f1} n_1}$$

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If $I_a r_a$ is negligibly small

$\therefore \quad E_{b1} = E_{b2} = V$

$E_{b1} = K I_{f1} n_1$

$E_{b2} = K I_{f2} n_2$

$\frac{I_{f1} n_1}{I_{f2} n_2} = 1$

$T_{L1} = T_{L2}$

$T_{e1} = K_T I_{f1} I_{a1} = T_{L1}$

$T_{e2} = K_T I_{f2} I_{a2} = T_{L2}$

$\frac{I_{f1} I_{a1}}{I_{f2} I_{a2}} = \frac{T_{L1}}{T_{L2}}$

Let $I_{f2} = 0.9 I_{f1}$

$\frac{I_{f1} n_1}{0.9 I_{f1} n_2} = 1$

$\frac{I_{f1} I_{a1}}{0.9 I_{f1} I_{a2}} = 1$

Or $n_2 = \frac{n_1}{0.9}$

Or $I_{a2} = \frac{I_{a1}}{0.9 I_{a2}}$

$n_2 = 1.1 n_1$ what $R_{f2} = ?$ $T_2 = ?$

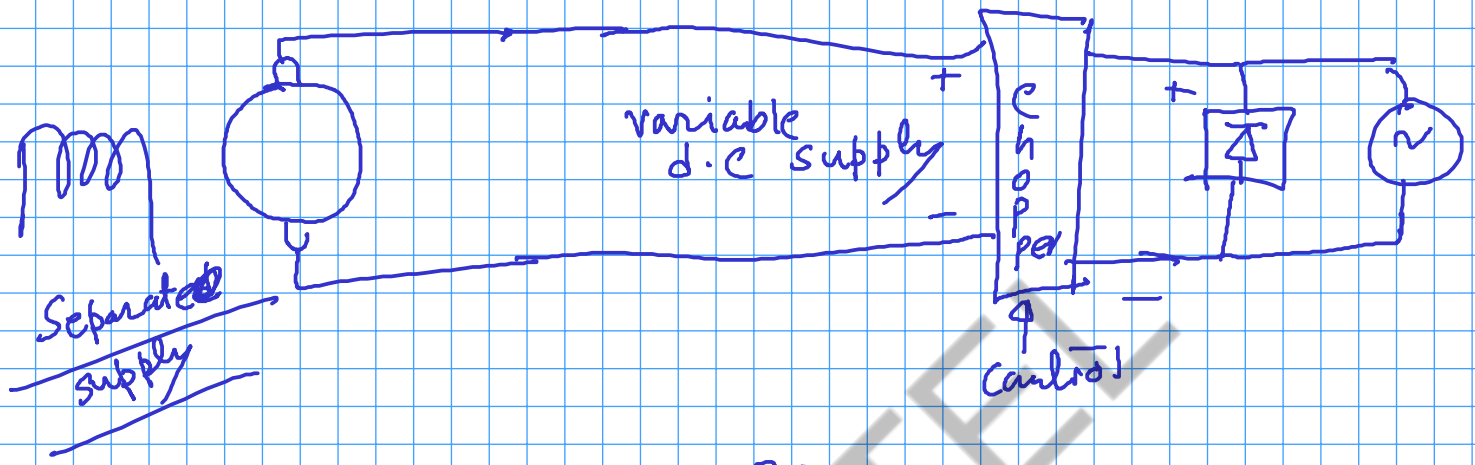
$\frac{I_{f1} n_1}{I_{f2} 1.1 n_1} = 1$

$I_{f2} = \frac{I_{f1}}{1.1}$

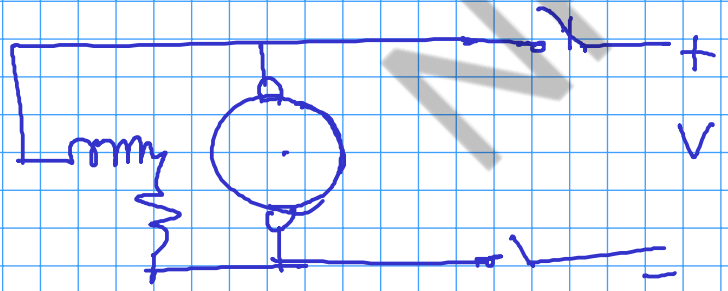
$R_{f2} = \frac{V}{I_{f2}}$

NPTEL

Lec-84



Electric braking of d.c shunt or separately excited motor



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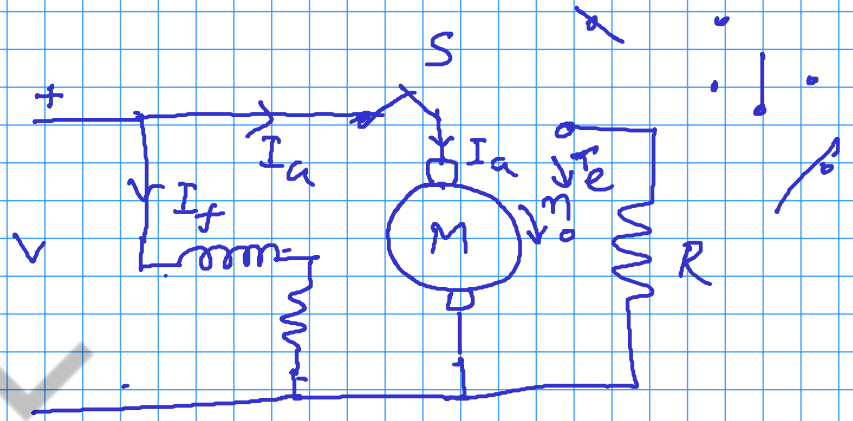
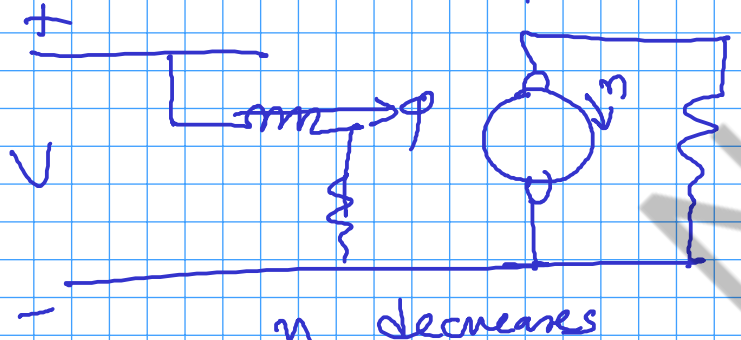
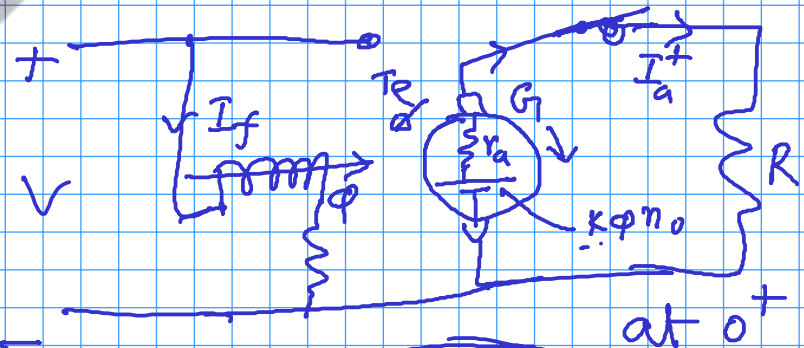
Braking
- Dynamic braking
- Plugging
- Regenerative braking



As time passes



n decreases



$T_b^+ = K\phi I_a^+$

at 0^+

$$I_a^+ = \frac{K\phi n_o}{R + r_a}$$

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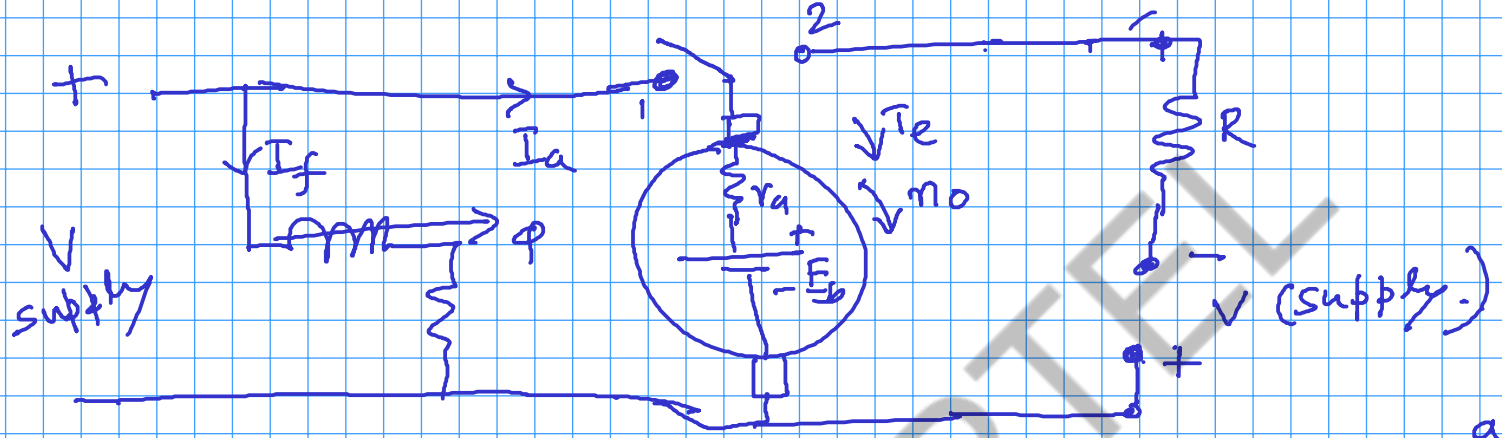
Plugging : ω → Braking

S in position 1 motoring mode



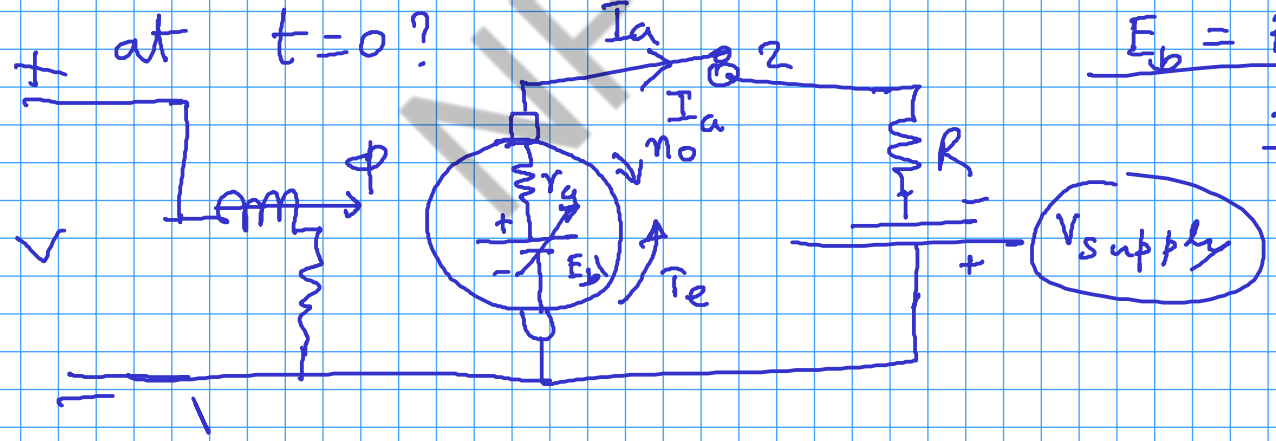
at $t=0^+$

$$E_b = K\phi n_0$$

E_b

$$I_a^+ = \frac{K\phi n_0 + V_{supply}}{r_a + R}$$

at $t=0$?



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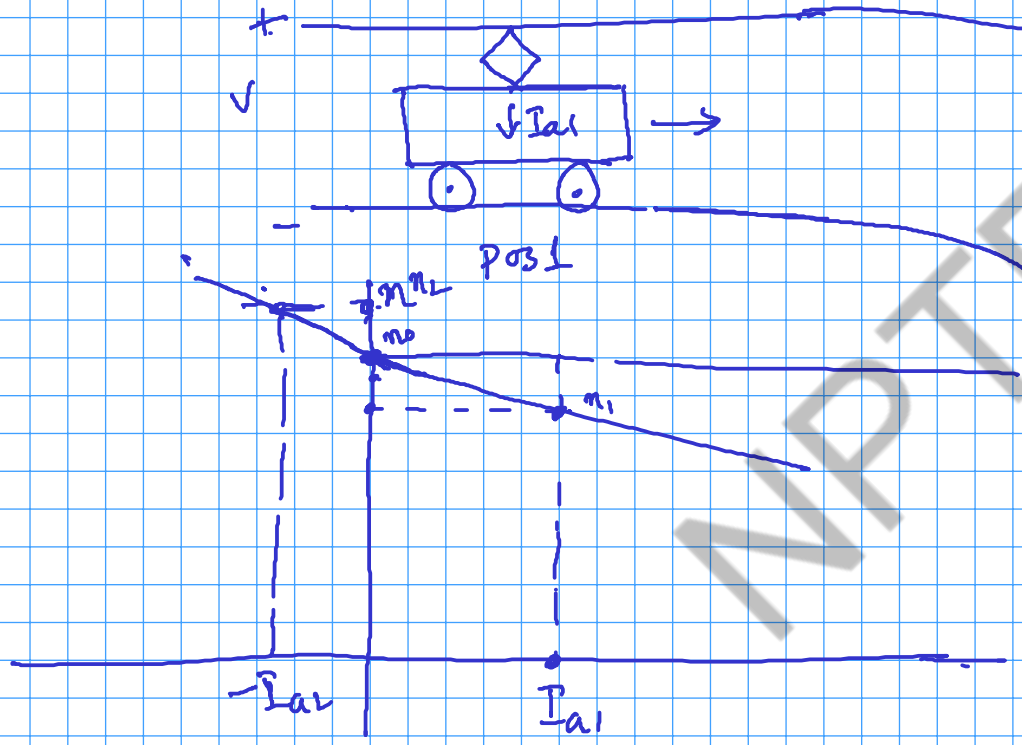
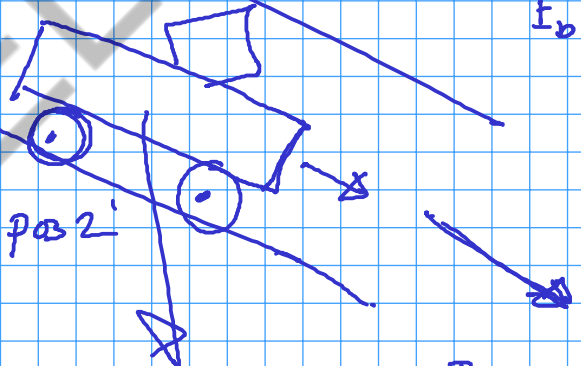
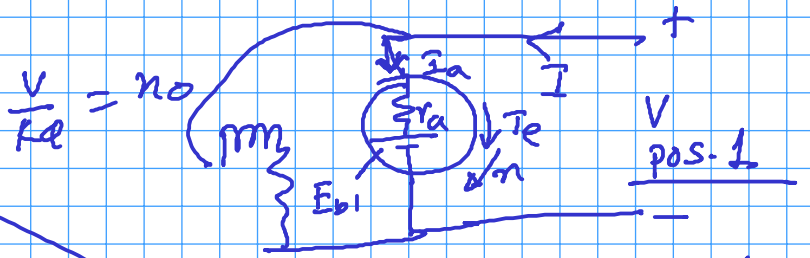
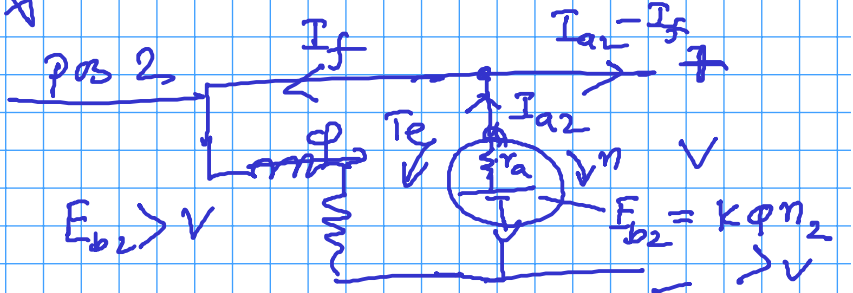
Regenerative Braking









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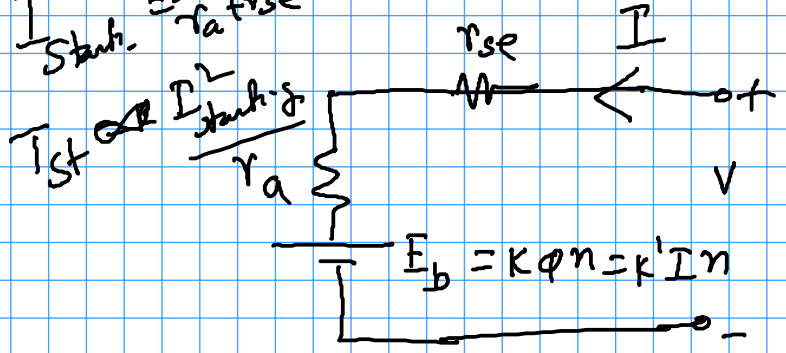
D.C Series motor

$I_{Starting} = \frac{V}{r_a + r_{se}}$

$I_{st} \propto I^2_{starting}$



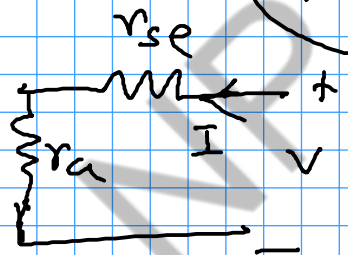
$E_b = K\phi n = K'In$

$I = \frac{V - E_b}{(r_a + r_{se})}$

$\phi \propto I$

$T_L = T_e = K_T I^2$

$I = \frac{V - KIn}{r_a + r_{se}}$



at $t = 0^+$

$I(0^+) = \frac{V}{r_a + r_{se}}$

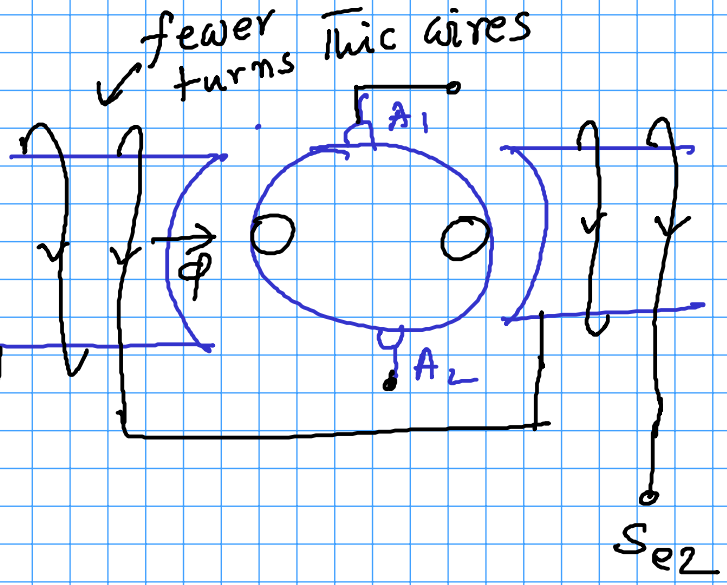
$T_e = K_T \phi I_a = K_T I^2$

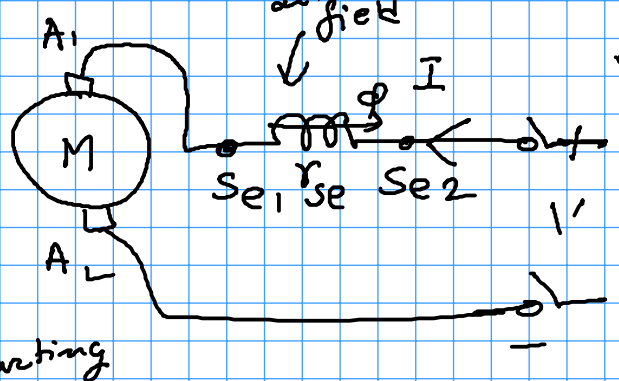
neglect Saturation.

Sh. motor

$T_e = K I_f I_a$

at the pt. of starting $I_a = V/r_a$





NPTEL