ECE 320 & ECE 329

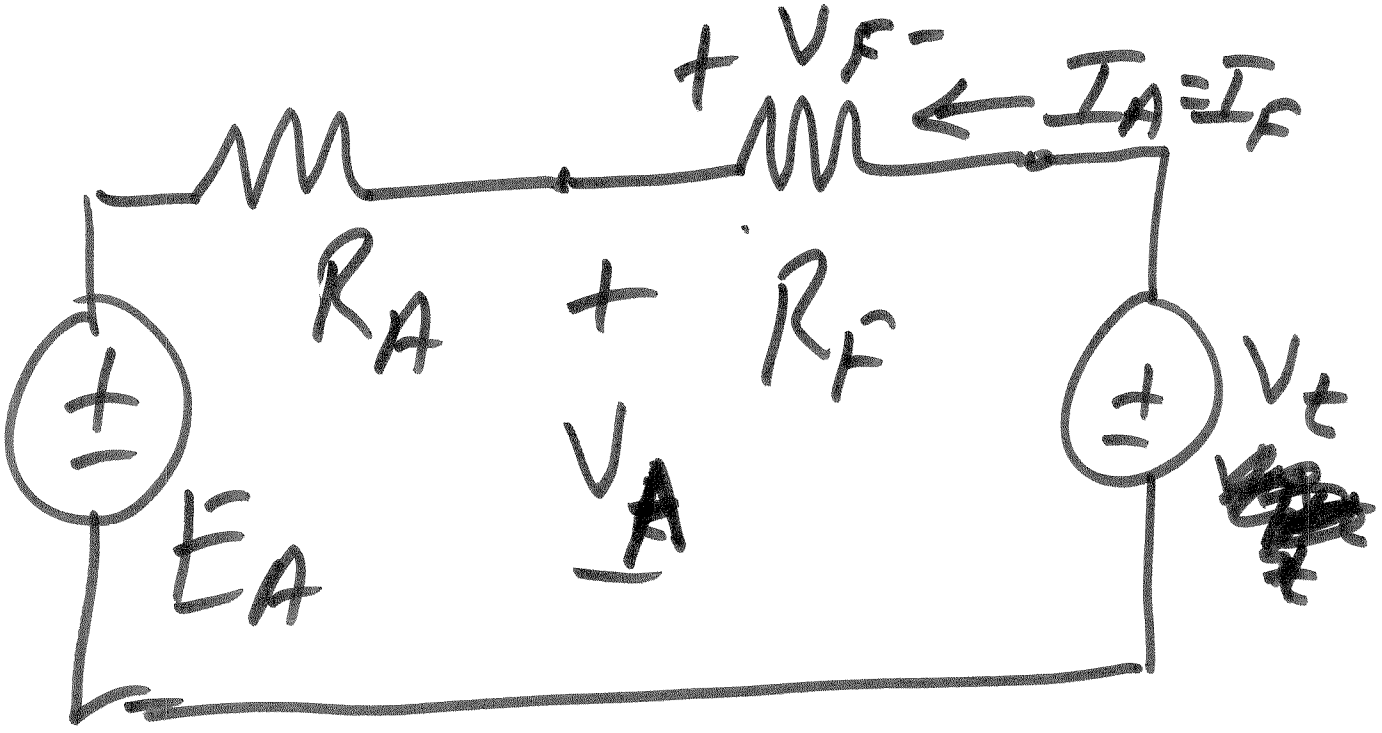
ENERGY SYSTEMS I

BACKGROUND STUDY IN ENERGY SYSTEMS

SESSION no. 27

SERIES MOTOR

- ⇒ SMALL MACHINE
- ⇒ UNIVERSAL: AC OR DC
- ⇒ HIGH TORQUE



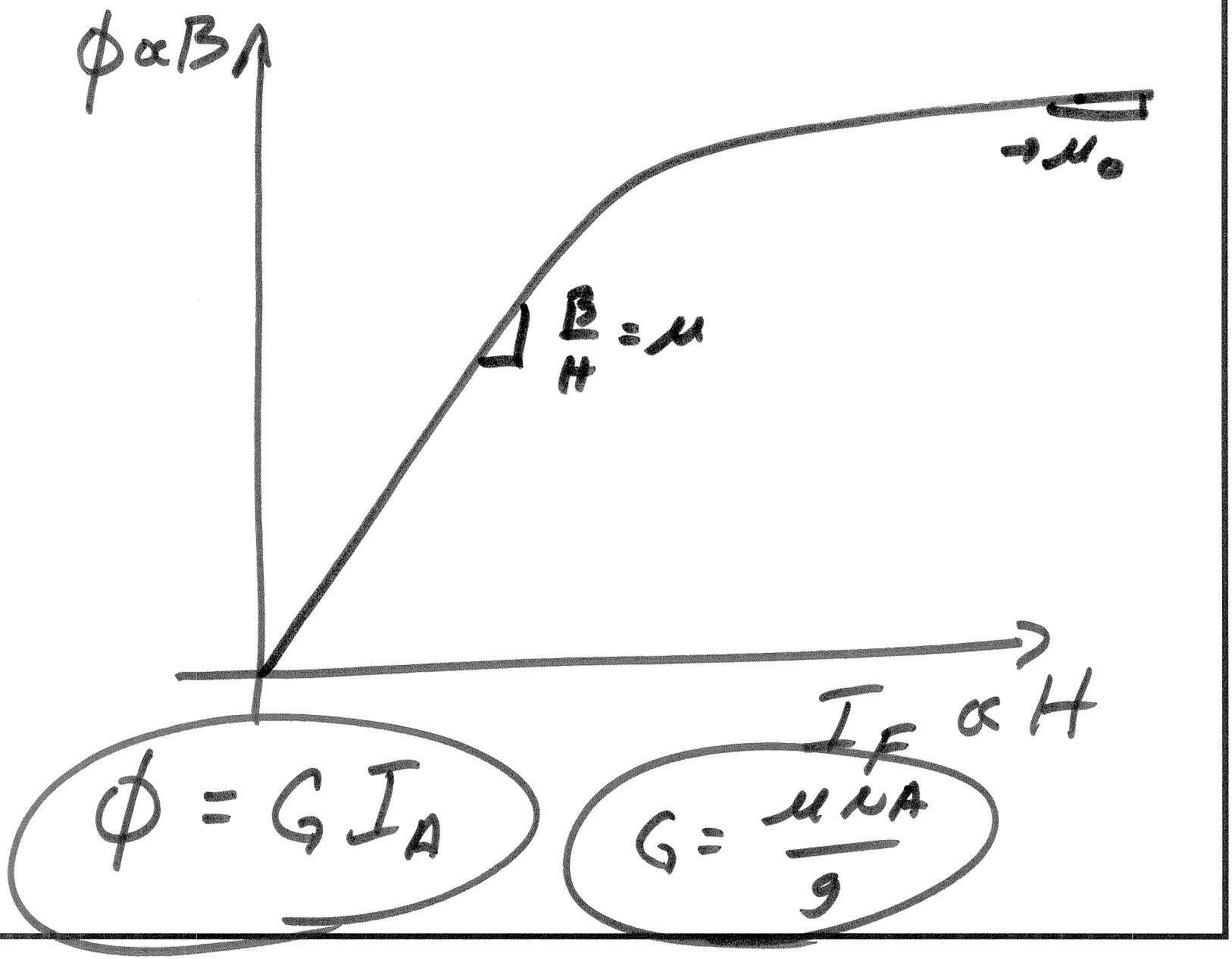
- SMALL NUMBER OF TURNS
- HEAVY WIRE
- HIGH START CURRENT

$$E_A = V_t - I_A (R_A + R_F)$$

$$E_A \simeq K \phi \omega$$

$$\tau = K \phi I_A$$

NOT LINEAR


$\phi \propto B$
$\rightarrow \mu_0$
$\frac{B}{H} = \mu$
$I_F \propto H$
$\phi = G I_A$
$G = \frac{\mu A}{9}$

$$T = K\phi I_A = KG I_A^2$$

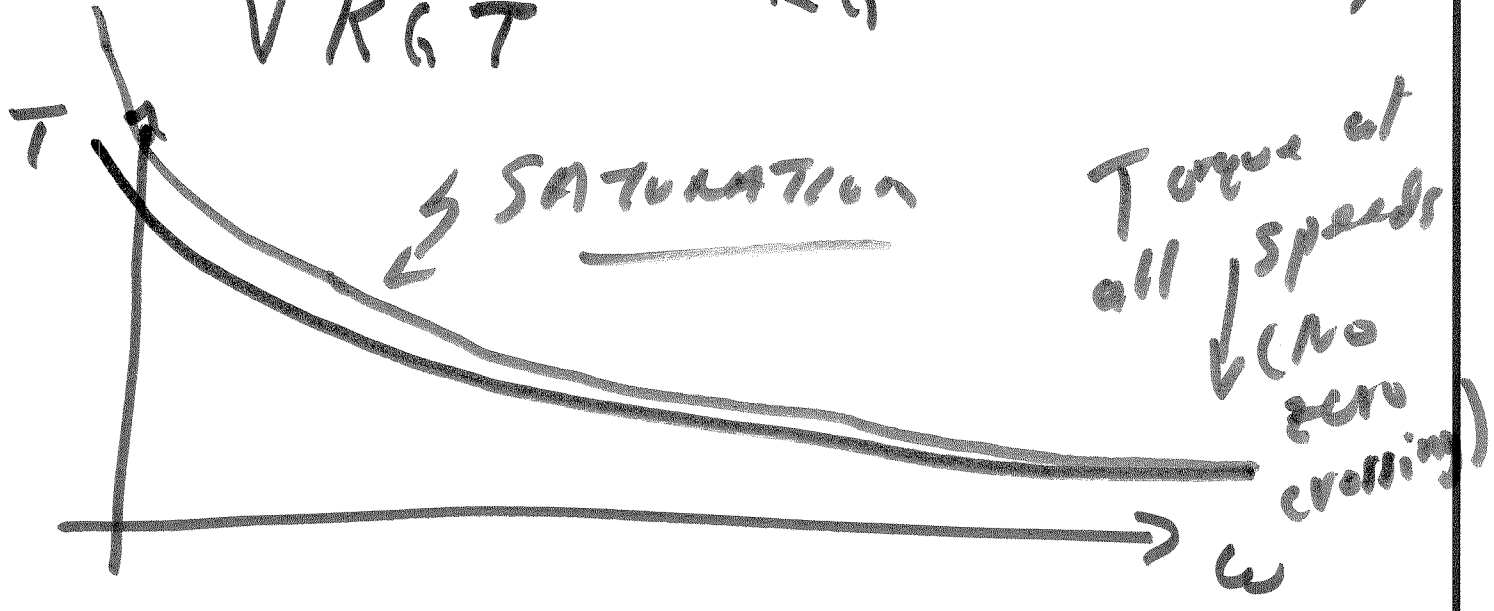
$$I_A = \sqrt{\frac{T}{KG}}$$

$$E_A = K\phi\omega = KG I_A \omega$$

$$E_A = KG\sqrt{\frac{T}{KG}}\,\omega$$

$$K_G \sqrt{\frac{T}{K_G}}\,\omega = V_t - \sqrt{\frac{T}{K_G}}\,(R_A + R_A)$$

$$\omega = \frac{V_t}{\sqrt{K_G T}} - \frac{1}{K_G}(R_A + R_A)$$



EXAMPLE

SERIES DC MOTOR

750 RPM NOMINAL RATED AT 100A, 250V = V_t

$R_A = 0.15\Omega$ $R_S = 0.10\Omega$

FOR 25A, $\Sigma\phi_d$ = 40% OF RATED

FIND SPEED AT 25A.

$$E_A = V_t - I_a(R_A + R_C)$$

$$E_A = 250V - (100A)(0.15 + 0.10)\Omega$$

$$E_A = 225V \quad \text{RATED}$$

$$E_A = V_t - I_A(R_A + R_F)$$

$$E_A = 250V - (25A)(0.15 + 0.10)\Omega$$

$$E_A = 243.75V \quad \text{LIGHTER LOAD}$$

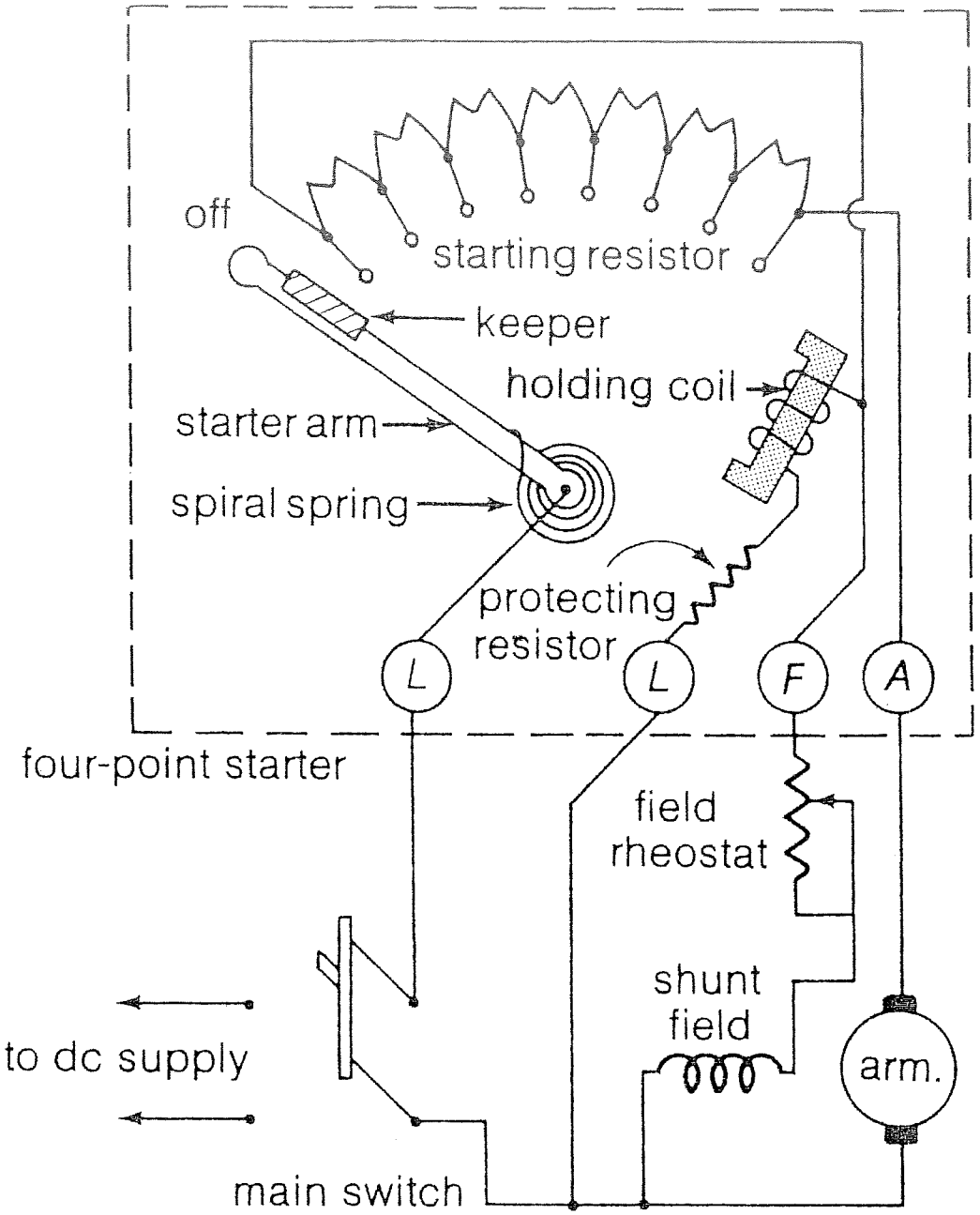
$$\frac{\phi_{RATED}}{\phi_{LIGHT\ LOAD}} = \frac{1}{0.4} = 2.5$$

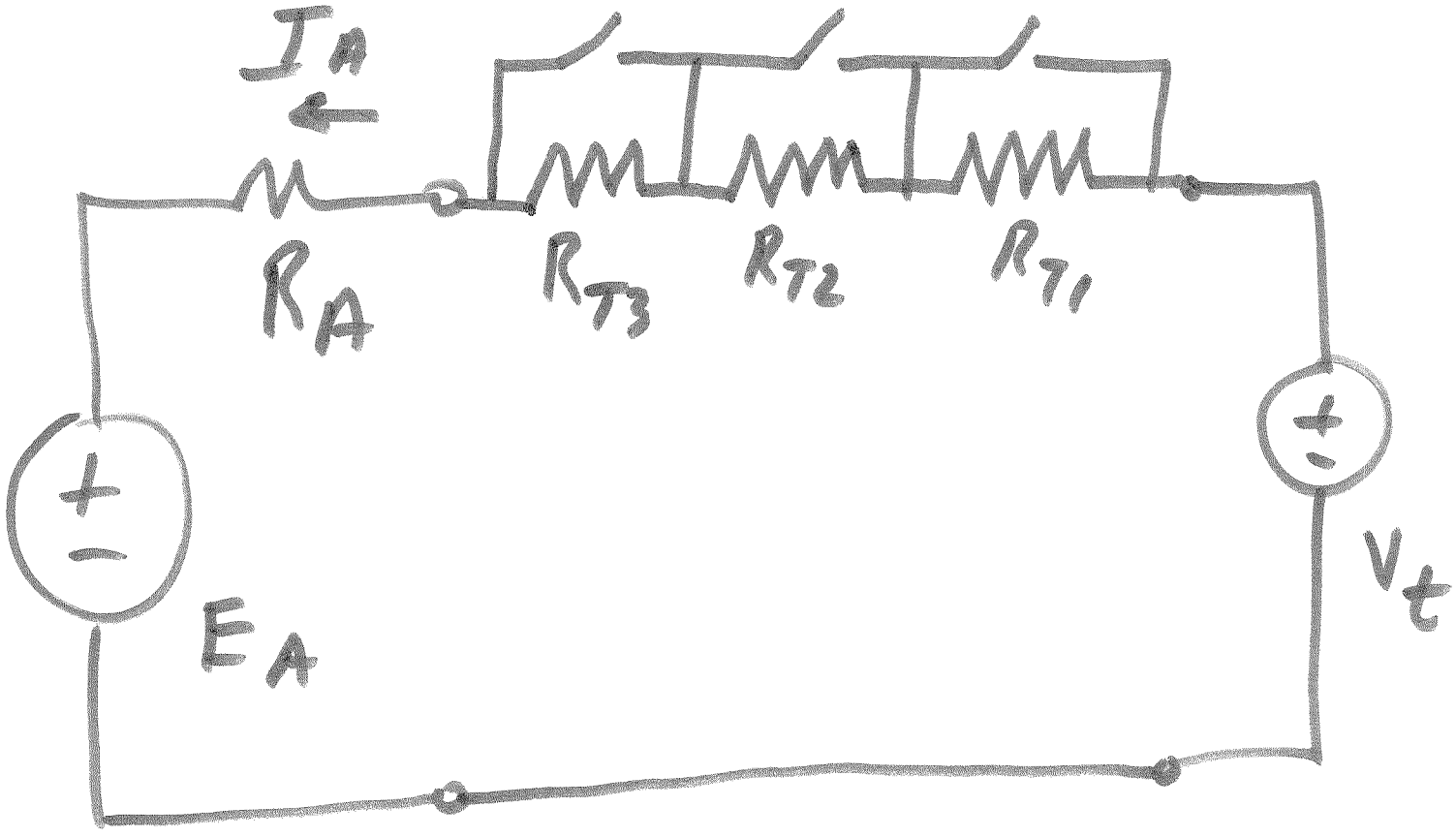
$$\frac{E_A}{E_A} = \frac{K\phi\omega}{K\phi\omega} \quad \begin{matrix} \leftarrow \text{RATED} \\ \leftarrow \text{LIGHT LOAD} \end{matrix}$$

$$\frac{225\text{V}}{243.75\text{V}} = 2.5\,\frac{710\text{ RPM}}{\omega_{LIGHT}}$$

$$\omega_{LIGHT} = 2031\text{ RPM}$$

FIELD WEAKENING DOMINATES THE INCREASED E_A.


off
starting resistor
keeper
holding coil
starter arm
spiral spring
protecting resistor
L
L
F
A
four-point starter
field rheostat
shunt field
arm.
to dc supply
main switch



STARTING

DC MOTOR START IT

230V = V_t

500 RPM = ω_{RATED} ⇐ $\frac{230V}{500 RPM} = 0.46 \frac{V}{RPM}$

37A = I_A RATED

0.39Ω = R_A

$R_{T1} = 1.5\Omega$ $R_{T2} = 0.78\Omega$ $R_{T3} = 0.39\Omega$

FIND STARTING BEHAVIOR

- SWITCH WHEN CURRENT FALLS TO RATED VALUE.

START $\omega = 0$

$$E_A = k\phi\omega = 0$$

$$I_{A0} = \frac{230\,V}{(1.56 + 0.78 + 0.39 + 0.39)\,\Omega}$$

$(1.56 + 0.78 + 0.39 + 0.39)\,\Omega = 3.12\,\Omega$

$I_{A0} = 73.7\,A$

MACHINE STARTS ... GETS TO $I_A = 37A$

$$E_{A1} = 230\,V - (3.12\,\Omega)(37\,A)$$

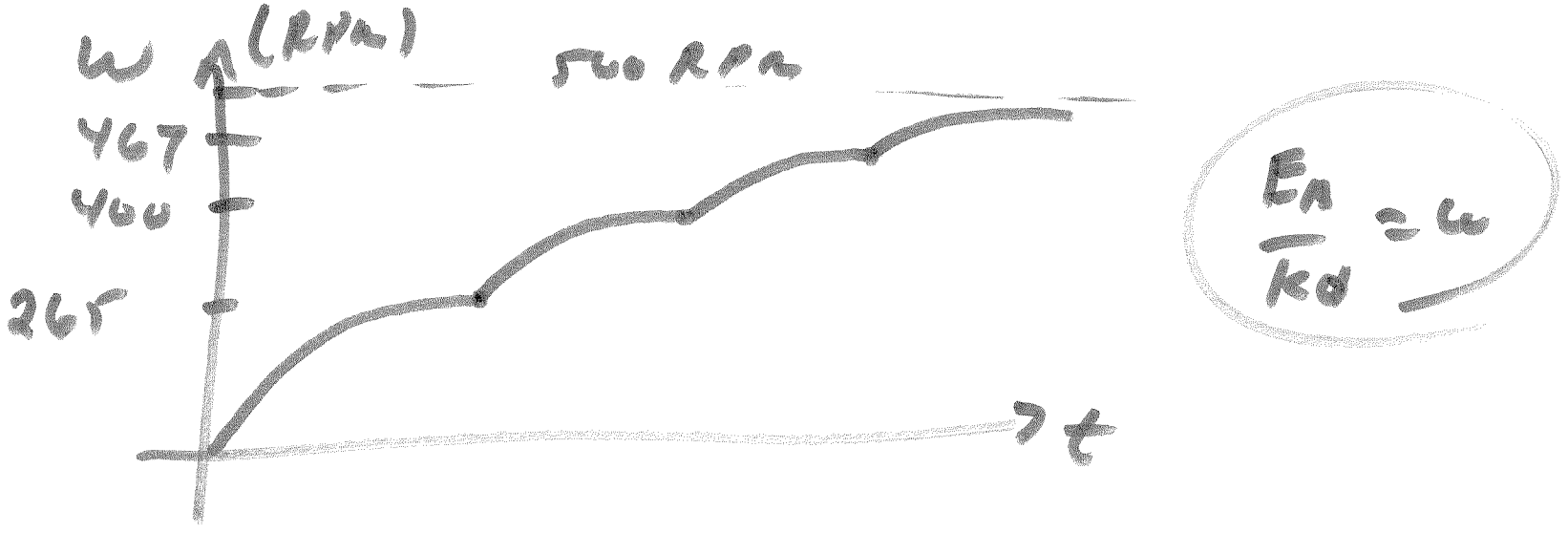
$$E_{A1} = \cancel{44.6\,V}\ 114.6\,V$$

SWITCH - SHUNT DCT

1.56 Ω

$$I_A = \frac{(230 - 114.6)\text{V}}{(3.12 - 1.56)\Omega} = 74\text{A}$$

$(0.78 + 0.39 + 0.39)\Omega$



$$\frac{E_A}{K\phi} = \omega$$

ECE 320

Energy Systems I

Lesson 27

DC Series Machines

DC Start Resistor Systems

If the series machine will start, it will come up to speed in most cases.

☹ Huge start current; it cannot run unloaded. (It will overspeed unloaded)