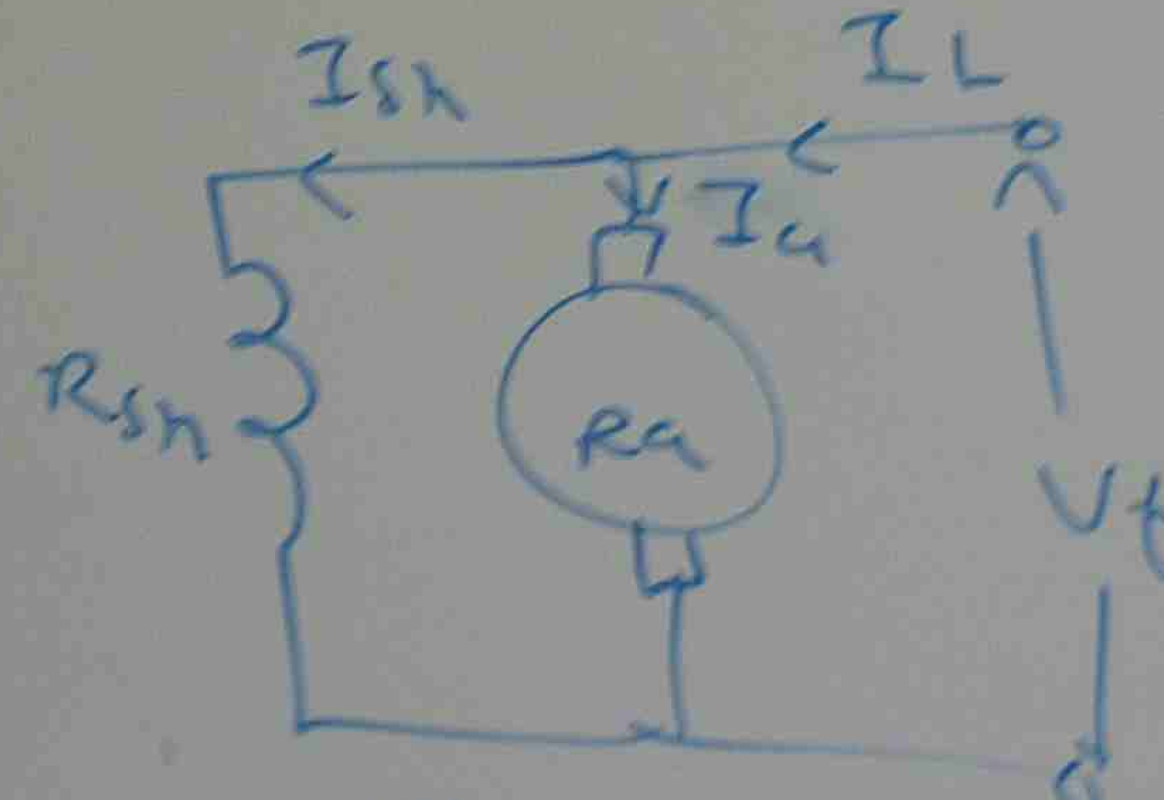
MAXIMUM EFFICIENCY

LOSSES

- IRON + FRICTIONAL LOSS — CONSTANT LOSS
- COPPER LOSS
  - FIELD COPPER LOSS — CONSTANT LOSS
  - ARMATURE COPPER LOSS — VARIABLE LOSS



$I_{sh} = \dfrac{V_t}{R_{sh}}$

SO LONG AS V_t IS CONSTANT I_{sh} IS CONSTANT & $I_{sh}^2 R_{sh}$ IS CONSTANT.

I_a DEPENDS ON

CONSTANT LOSSES

VARIABLE LOSSES

MAXIMUM EFF

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TOTAL LOSS

...CY

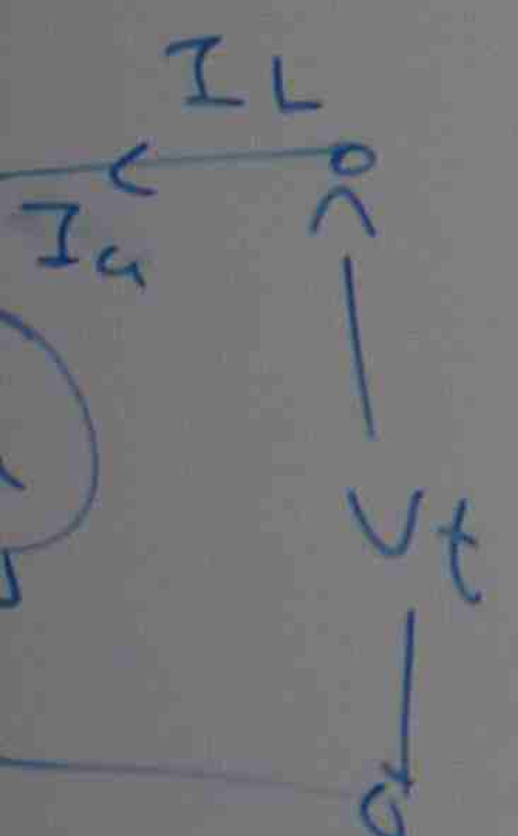
COPPER LOSS

...D ...ER LOSS

ARMATURE COPPER LOSS

...ANT LOSS

VARIABLE LOSS



SO LONG AS V_t IS CONSTANT I_{sh} IS CONSTANT & $I_{sh}^2 R_{sh}$ IS CONSTANT.

I_a DEPENDS ON LOAD CONDITION

CONSTANT LOSSES = IRON + FRICTIONAL LOSSES + SHUNT FIELD COPPER LOSS

VARIABLE LOSSES = ARMATURE COPPER LOSS + SERIES FIELD COPPER LOSS

MAXIMUM EFFICIENCY OCCURS WHEN CONSTANT LOSS IS EQUAL TO VARIABLE LOSS.

SHUNT MACHINE

VARIABLE LOSS = $I_a^2 R_a$

CONSTANT LOSS = VARIABLE LOSS = $I_a^2 R_a$

TOTAL LOSSES = VARIABLE LOSS + CONSTANT LOSS

$= I_a^2 R_a + I_a^2 R_a = 2 I_a^2 R_a$

MAXIMUM EFF...

EX A 60 KW...

RESISTANCE OF ...

EFFICIENCY 91...

(a) TOTAL LOA...

(b) STRAY POW...

SHUNT FIELD COPPER LOSS

...RIES FIELD ...OPPER LOSS

CONSTANT LOSS

...SS = $I_a^2 R_a$

...NSTANT LOSS

... = $2 I_a^2 R_a$

$$\text{MAXIMUM EFFICIENCY} = \frac{\text{OUT PUT POWER}}{\text{IN PUT POWER}} \times 100$$

$$= \frac{\text{OUT PUT POWER}}{\text{OUTPUT POWER} + \text{TOTAL LOSSES}} \times 100$$

$$\eta_{max} = \frac{V_t I_L}{V_t I_L + 2 I_a^2 R_a} \times 100$$

Ex A 60 KW, 250 V SHUNT GENERATOR HAS AN ARMATURE CIRCUIT RESISTANCE OF 0.05 Ω, FIELD RESISTANCE OF 50 Ω AND A MAXIMUM EFFICIENCY 91%. CALCULATE

(a) TOTAL LOAD FOR WHICH THE EFFICIENCY IS APPROXIMATELY A MAXIMUM

(b) STRAY POWER LOSS

$$\eta_{max} = \frac{V_t I_L}{V_t I_L + 2 I_a^2 R_a} \times 100$$

$$91 = \frac{V_t I_L}{V_t I_L + 2 I_a^2 R_a} \times 100$$

$R_{sh} = 50\Omega$

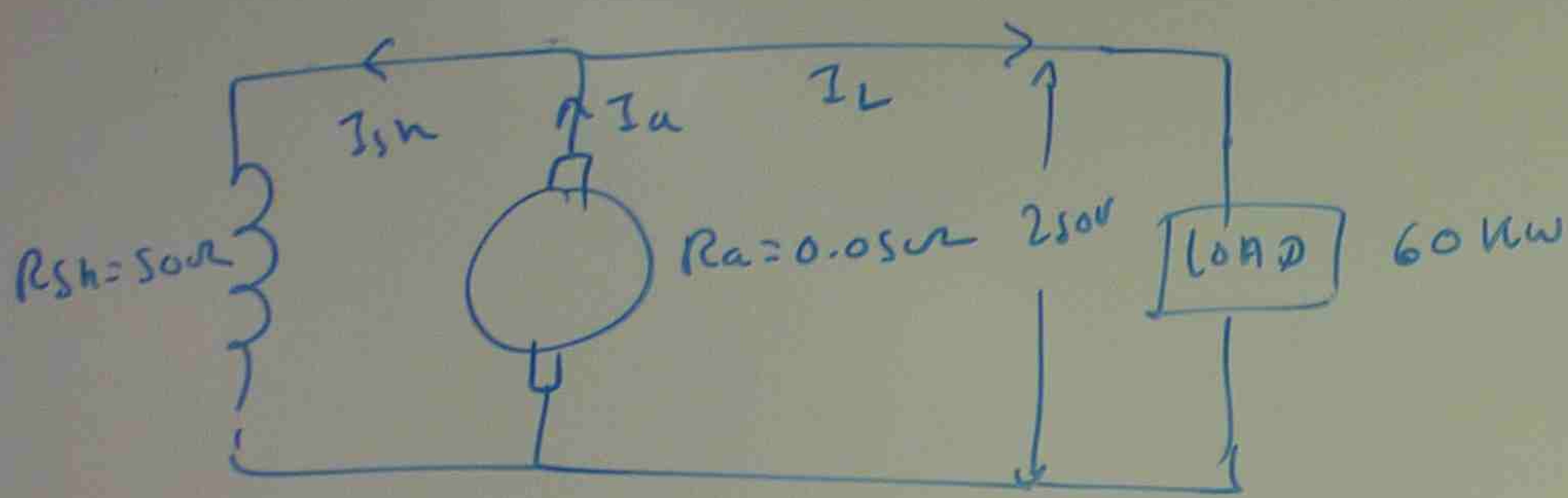
91 =

$I_a = I$...

I_s...

I_a...

0.4...



$V_t = 250V$

$$91 = \frac{250\, I_L}{250 I_L + 2\, I_a^2 \times 0.05} \times 100$$

$$I_a = I_L + I_{sh}$$

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{250}{50} = 5 \text{ Amp}$$

$$I_a = I_L + 5$$

$$0.91 = \frac{250\, I_L}{250 I_L + 2 \times (I_L + 5)^2 \times 0.05}$$

$$\begin{array}{r} I_L + 5 \\ \times\; I_L + 5 \\ \hline I_L^2 + 5I_L \\ 5I_L + 25 \\ \hline I_L^2 + 10I_L + 25 \end{array}$$

$$0.91 = \frac{250\, I_L}{250 I_L + 0.1(I_L^2 + 10 I_L + 25)}$$

$$0.91 = \frac{250\, I_L}{250 I_L + 0.1 I_L^2 + I_L + 2.5}$$

$$0.91(250 I_L + 0.1 I_L^2 + I_L + 2.5) = 250 I_L$$

$$227.5 I_L + 0.091 I_L^2 + 0.91 I_L + 2.275 = 250 I_L$$

$$0.091 I_L^2 - 21.59 I_L + 2.275 = 0$$

$$A x^2 + B x + C = 0$$

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$I_L = \frac{-(-21.59) \pm \sqrt{(-21.59)^2 - 4 \times 0.091 \times 2.275}}{2 \times 0.091}$$

$$= 247.2 \text{ Amp.}$$

$I_L + 5$
$I_L + 5$

$I_L^2 + 5I_L$
$5I_L + 25$

$I_L^2 + 10I_L + 25$

L

$.1(I_L^2 + 10I_L + 25)$

$.1 I_L^2 + I_L + 2.5$

$I_L^2 + I_L + 2.5) = 250 I_L$

$.091 I_L^2 + 0.91 I_L + 2.275 = 250 I_L$

$.54 I_L + 2.275 = 0$

$x \quad + c = 0$

$= \dfrac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

$\dfrac{4) \pm \sqrt{(-21.54)^2 - 4 \times 0.091 \times 2.275}}{2 \times 0.091}$

2 Amp.

STRAY loss $= I_a^2 R_a - V_t \times I_{field}$

$I_a = I_L + I_{sh} = 247.2 + 5 = 252.2$ Amp

$I_{field} = I_{sh} = 5$ Amp

STRAY loss $= I_a^2 Ra - V_t I_{sh}$

$= (252.2)^2 \times 0.05 - 250 \times 5$

$= 1800$ WATT.

STRAY LOSS $= I_a^2 R_a - V_t \times I_{field}$

$I_a = I_L + I_{sh} = 247.2 + 5 = 252.2$ AMP

$I_{field} = I_{sh} = 5$ AMP

STRAY LOSS $= I_a^2 R_a - V_t I_{sh}$

$= (252.2)^2 \times 0.05 - 250 \times 5$

$= 1800$ WATT.

MACHINE TEMPERATURE RISE

MACHINE TEMPERATURE RISE CAN BE MEASURED BY

(a) THERMOMETER

(b) EMBEDDED THERMOCOUPLE (OR) THERMISTOR

(c) COMPUTATION FROM HOT AND COLD RESISTANCE

$$\frac{R_F}{R_{RT}} = \frac{234.5 + T_F}{234.5 + T_{RT}}$$

R_F = FINAL RESISTANCE

R_{RT} = RESISTANCE AT ROOM TEMPERATURE

T_F = FINAL TEMPERATURE

T_{RT} = ROOM TEMPERATURE (25°C)

Ex THE RESISTANCE OF AN ARMATURE WINDING AT 25°C WAS FOUND TO BE 0.26Ω. AFTER A HEAT RUN, IT BECOMES 0.296Ω. CALCULATE TEMPERATURE RISE OF THE WINDING.

$T_{RT} = 25°C$, $R_{RT} = 0.26\Omega$

$R_F = 0.296\Omega$

$T_F = ?$

$$\frac{R_F}{R_{RT}} = \frac{234.5 + T_F}{234.5 + T_{RT}}$$

$$\frac{0.296}{0.26} = \frac{234.5 + T_F}{234.5 + 25}$$

$$\frac{0.296}{0.26}(234.5 + 25) - 234.5 = T_F$$

$$T_F = 61°C$$

TEMPERATURE RISE $= T_F - T_{RT} = 61 - 25 = 36°C$

ANALY

ROTATION

(a) B

(b) WI

(c) BR

(d) H

(e) -

HYSTERESI

- DEPENDS

- FREQUE

f

- FLU

- MAS

WINDING AT 25°C WAS FOUND TO
IT BECOMES 0.296Ω.
THE WINDING.

0.26Ω

0.296Ω

$s = T_F$

-61°C

$= 61 - 25 = 36°C$

ANALYSIS OF POWER LOSSES IN DC MACHINE

ROTATIONAL LOSSES

(a) BEARING FRICTION
(b) WIND FRICTION
(c) BRUSH FRICTION —— DEPENDS ON KIND OF BRUSH
(d) HYSTERESIS
(e) IRON EDDY CURRENT LOSSES

HYSTERESIS LOSS

- DEPENDS ON QUALITY OF IRON
- FREQUENCY OF AC CURRENT

$$f = \frac{PN}{120} \quad Hz$$

- FLUX DENSITY IN ARMATURE CORE
- MASS OF IRON

$P_h = K$

$K_h =$

$f = F$

$B = m$

$m =$

EDDY CURR

DC MACHINE

— DEPENDS ON KIND OF BRUSH

OSSES

RE CORE

$$\boxed{P_h = K_h \, f \, B^{1.6} \, m \quad \text{WATT}}$$

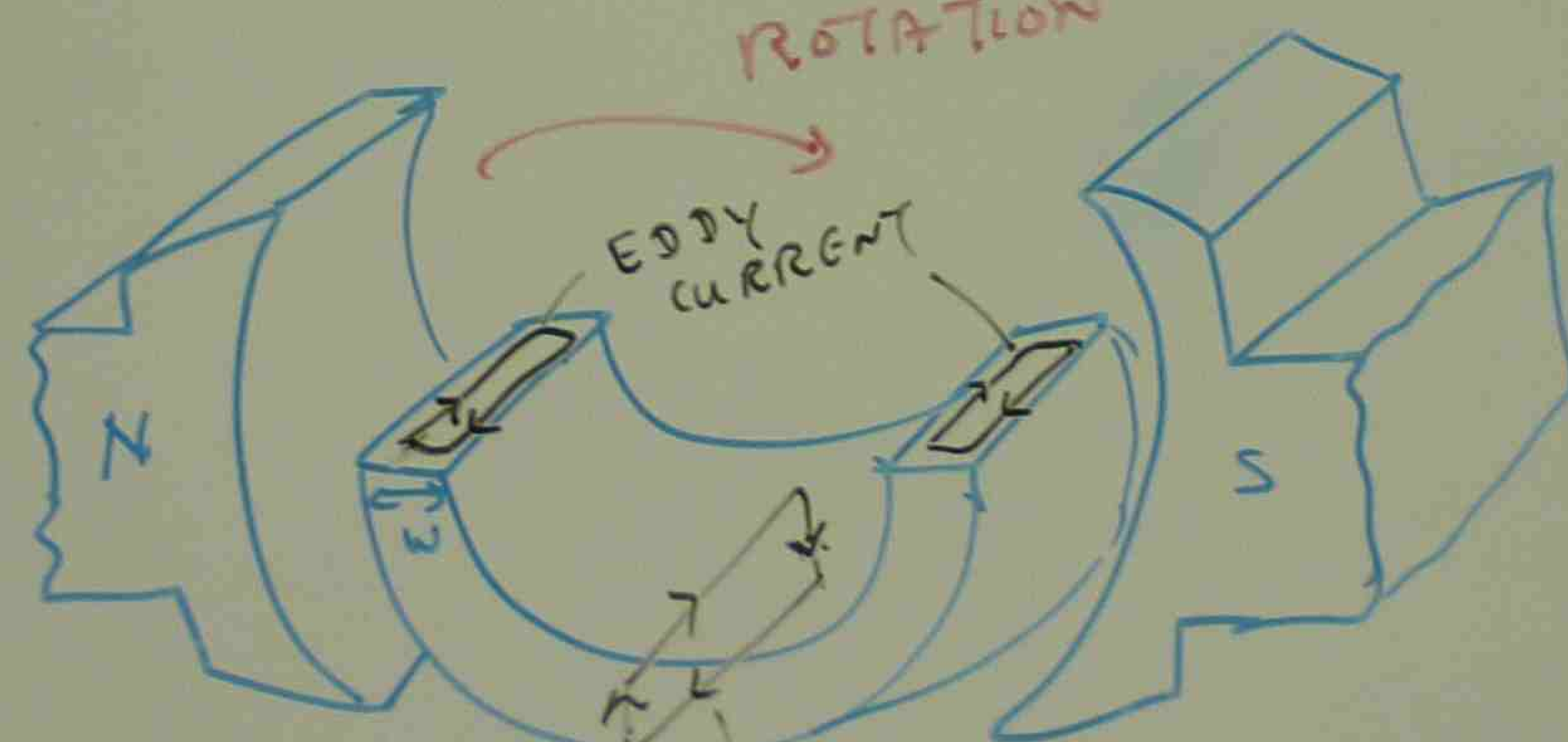
K_h = CONSTANT DEPENDING ON MATERIAL & UNIT USED

f = FREQUENCY (Hz)

B = MAXIMUM FLUX DENSITY (T)

m = MASS OF CORE (Kg)

EDDY CURRENT PATHS IN SOLID CORE



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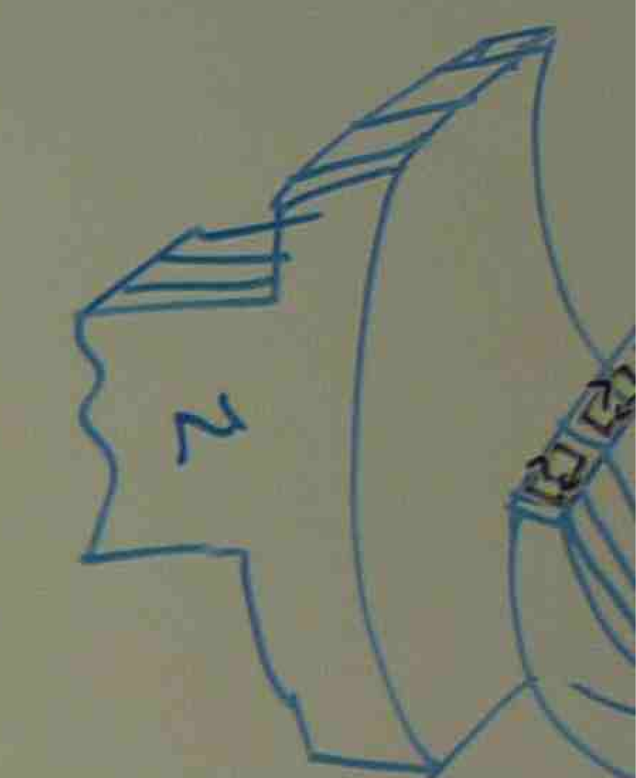


THE EDD

— FREQUE

(OR) FL

- THE TH

LAMIN

- THE FL

- THE U

WATT

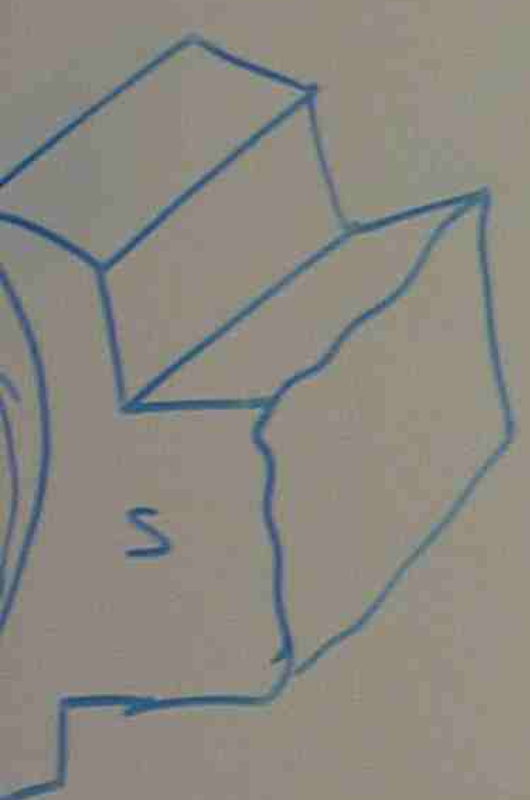
G ON MATERIAL & UNIT USED

HZ)

DENSITY (T)

(Kg)

SOLID CORE



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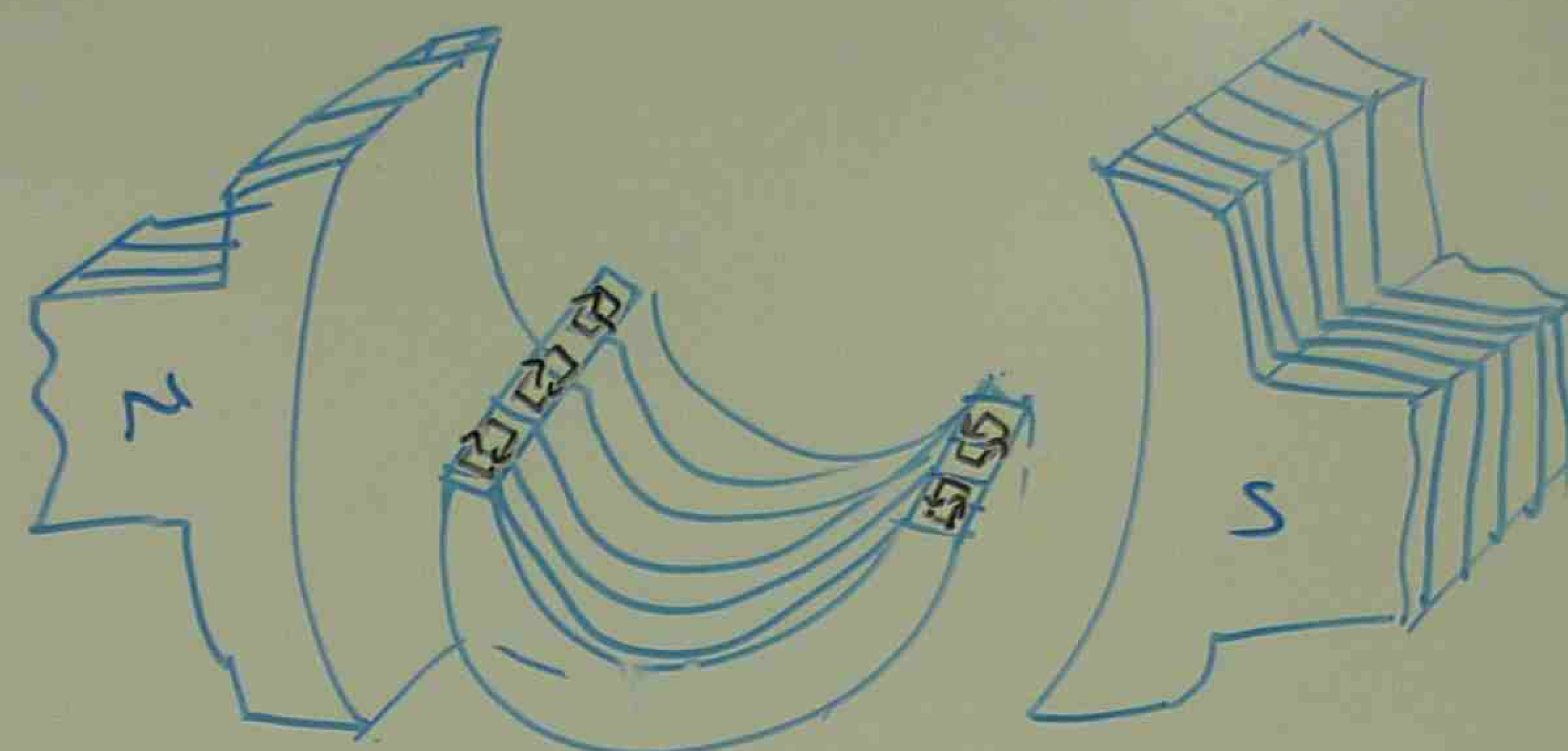
EDDY CURRENT PATHS IN LAMINATION



THE EDDY CURRENT LOSS DEPENDS ON

- FREQUENCY OF THE ALTERNATING CURRENT (OR) FLUX IN ARMATURE CORE
- THE THICKNESS OF THE ARMATURE CORE LAMINATION
- THE FLUX DENSITY IN THE CORE
- THE VOLUME OF THE IRON.

$\boxed{P_E = K_e}$

P_E = EDDY CU

K_e = CONSTANT

THE IRO

THE FAC

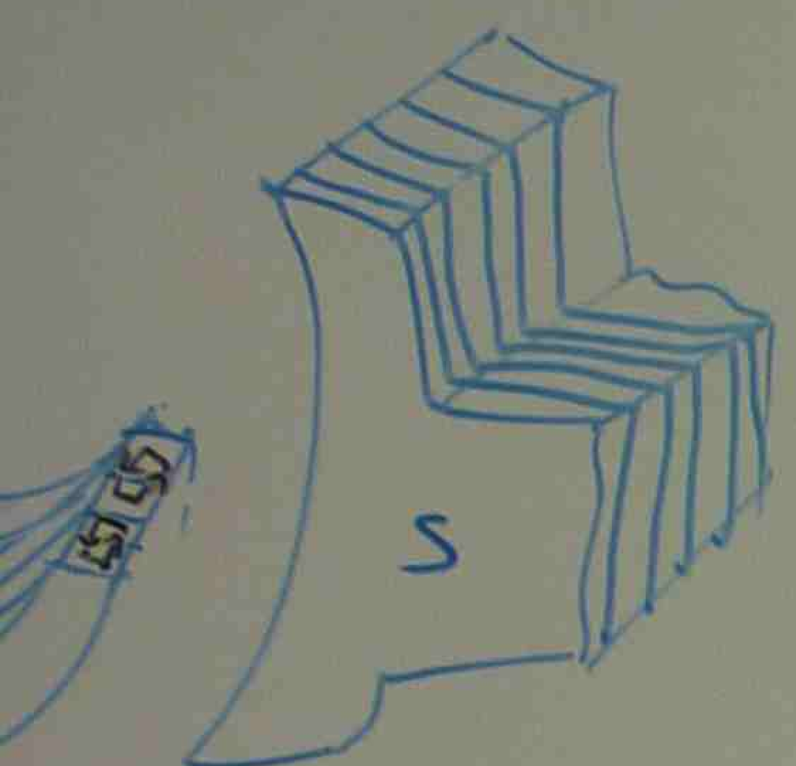
f = FREQUEN

t = THICKNE

B = MAXIM

V = VOLUM

PATHS IN LAMINATION



RENT LOSS DEPENDS ON

F THE ALTERNATING CURRENT

ARMATURE CORE

S OF THE ARMATURE CORE

SITY IN THE CORE

OF THE IRON.

$$\boxed{P_E = K_e f^2 t^2 B^2 V}$$ WATT

P_E = EDDY CURRENT LOSS WATT

K_e = CONSTANT DEPENDING ON THE RESISTIVITY OF THE IRON AND DIMENSIONS EMPLOYED FOR THE FACTOR

f = FREQUENCY HZ

t = THICKNESS OF LAMINATION m

B = MAXIMUM FLUX DENSITY IN CORE T

V = VOLUME OF IRON IN CORE

STRAY LOSS = I_a^2

$I_a = I_L +$

$I_{field} = I_s$

STRAY LOSS = I_a

= (2

=

MACHINE

MACHINE TEM

BY (a) THER

(b) EMI

(c) CON

R

C MACHINE

DEPENDS ON KIND OF BRUSH

CORE

$$\boxed{P_h = K_h f B^{1.6} m \quad \text{WATT}}$$

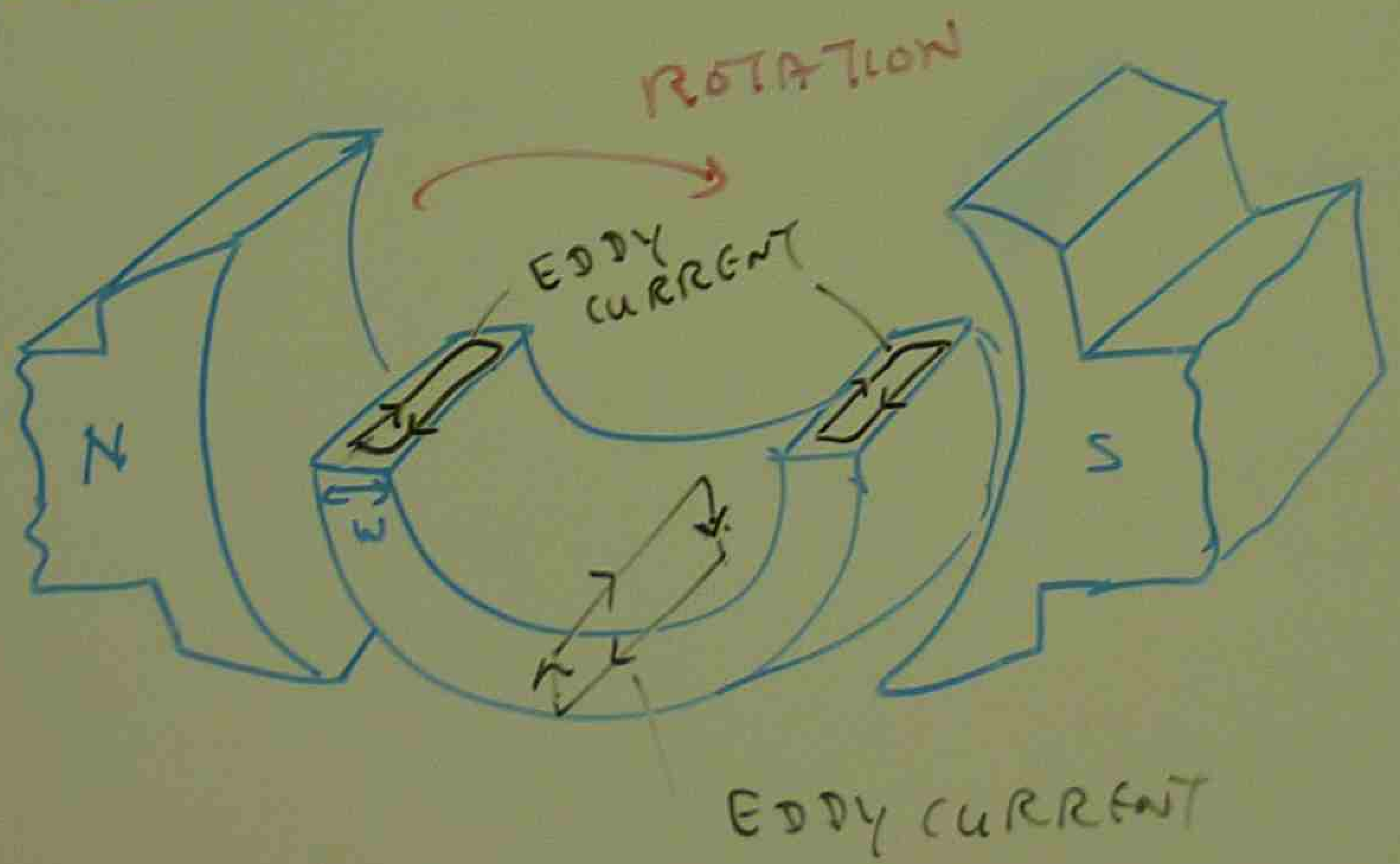
K_h = CONSTANT DEPENDING ON MATERIAL & UNIT USED

f = FREQUENCY (HZ)

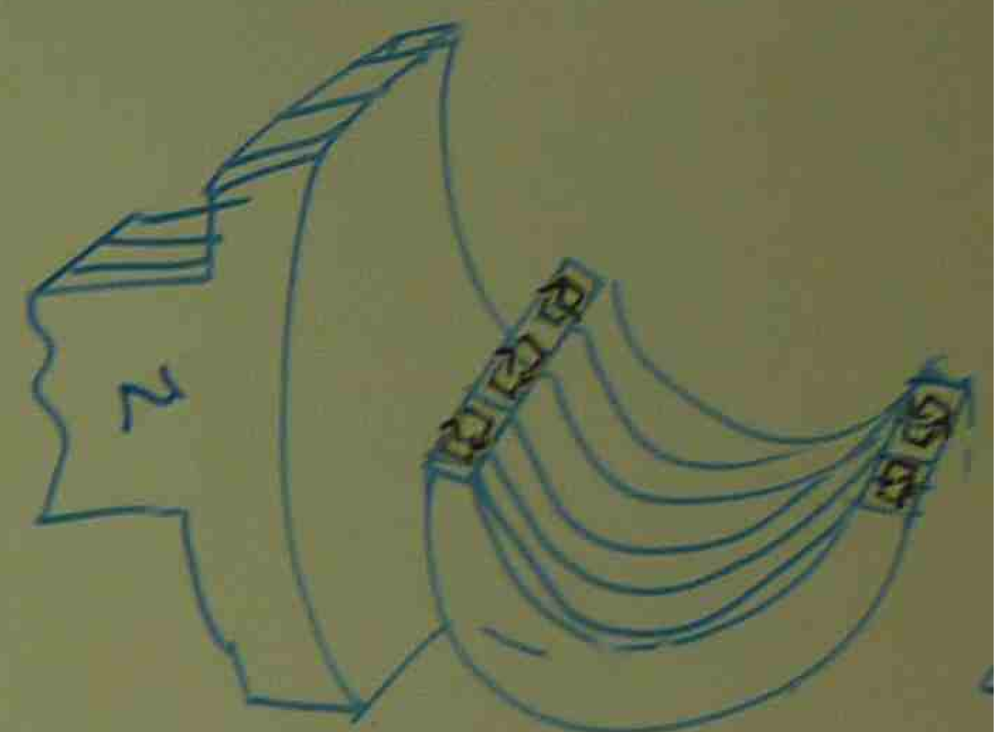
B = MAXIMUM FLUX DENSITY (T)

m = MASS OF CORE (Kg)

EDDY CURRENT PATHS IN SOLID CORE



EDDY CURRENT PATHS



THE EDDY CURRENT

— FREQUENCY OF

(OR) FLUX IN A

- THE THICKNESS OF LAMINATION

- THE FLUX DENSITY

- THE VOLUME OF

$\boxed{\text{WATT}}$

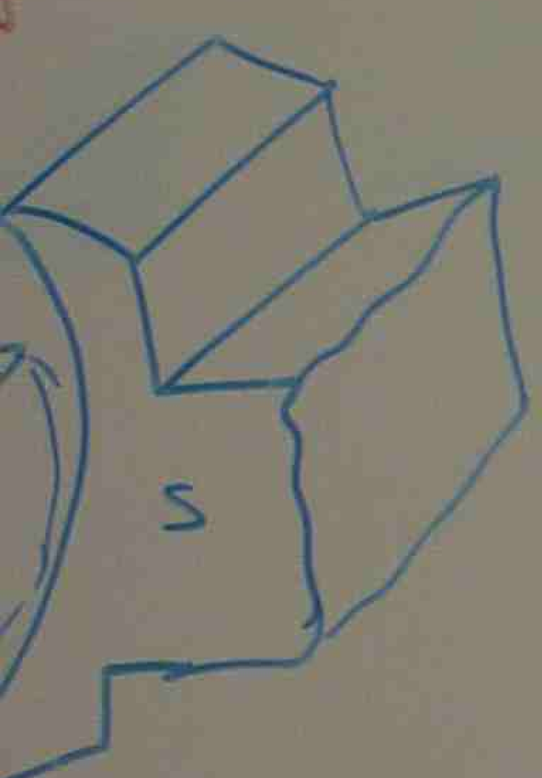
...G ON MATERIAL & UNIT USED

HZ)

DENSITY (T)

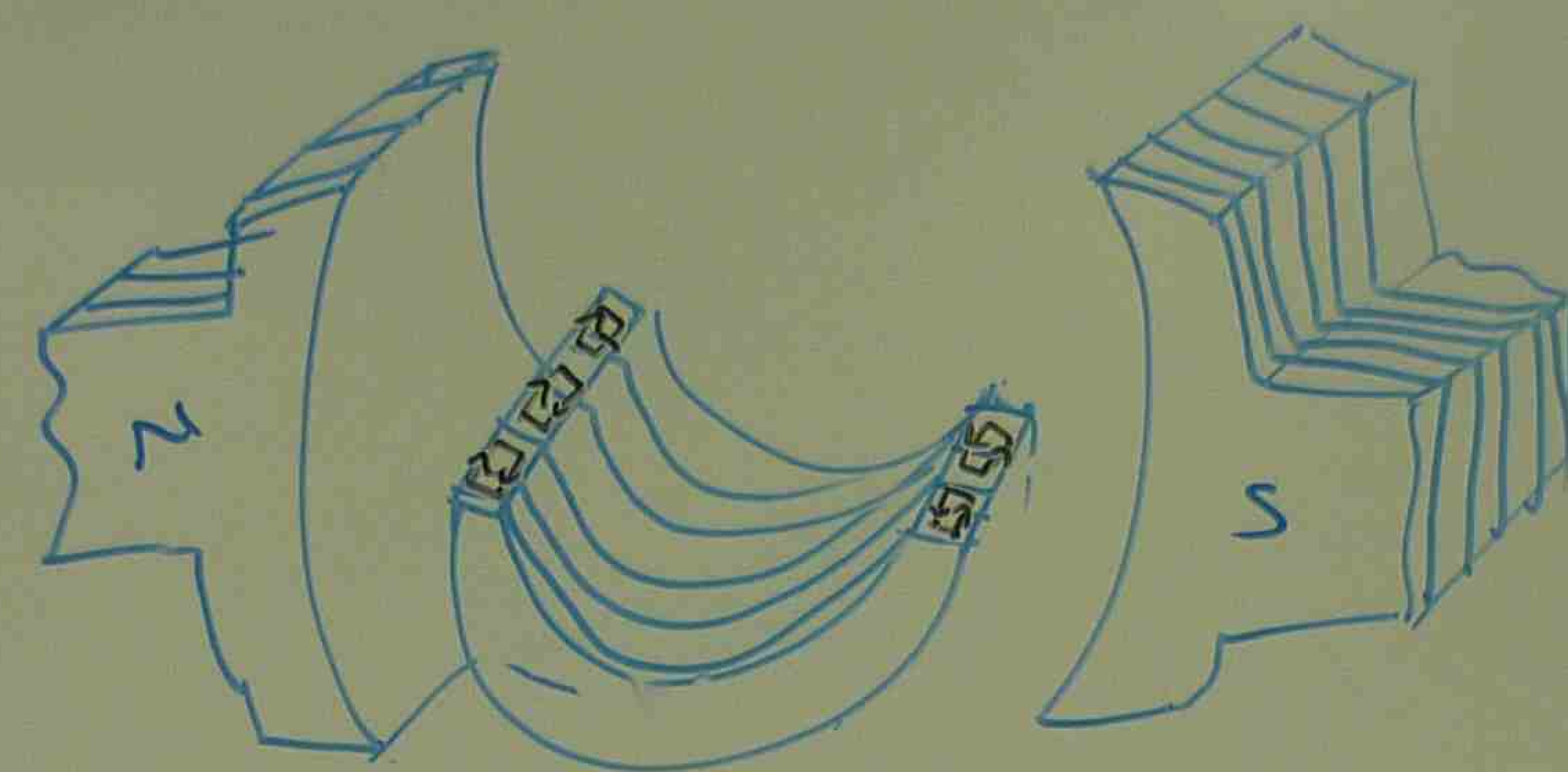
(Kg)

SOLID CORE



URRENT

EDDY CURRENT PATHS IN LAMINATION



THE EDDY CURRENT LOSS DEPENDS ON

- FREQUENCY OF THE ALTERNATING CURRENT (OR) FLUX IN ARMATURE CORE
- THE THICKNESS OF THE ARMATURE CORE LAMINATION
- THE FLUX DENSITY IN THE CORE
- THE VOLUME OF THE IRON.

$$\boxed{P_E = K_e f^2 t \ldots}$$

P_E = EDDY CURRENT ...

K_e = CONSTANT DEPEN...
THE IRON AND ...
THE FACTOR ...

f = FREQUENCY

t = THICKNESS OF ...

B = MAXIMUM F...

V = VOLUME OF ...

...TOR IN LAMINATION

...NT LOSS DEPENDS ON
... THE ALTERNATING CURRENT
...ARMATURE CORE
... OF THE ARMATURE CORE

...Y IN THE CORE
...THE IRON.

$$\boxed{P_E = K_e f^2 t^2 B^2 V}$$ WATT

P_E = EDDY CURRENT LOSS   WATT

K_e = CONSTANT DEPENDING ON THE RESISTIVITY OF THE IRON AND DIMENSIONS EMPLOYED FOR THE FACTOR

f = FREQUENCY   Hz

t = THICKNESS OF LAMINATION   m

B = MAXIMUM FLUX DENSITY IN CORE   T

V = VOLUME OF IRON IN CORE   (m^3)

EX CALCULATE EDDY...
GIVEN DC MACHIN...

$K_e = 3$, K_h...

THICKNESS OF LAM...

CORE FLUX DENSITY = ...

VOLUME OF CORE = ...

MASS OF CORE = ...

$P_h = K_h f B$...

= 2 x 60...

= 120 x 3...

= 2388...

= 2388...

ATT

STIVITY OF

YES FOR

m

RE I

(m^3)

EX CALCULATE EDDY CURRENT AND HYSTERESIS LOSSES FOR THE GIVEN DC MACHINE

$K_e = 3$, $K_h = 2$ FREQUENCY = 60 HZ

THICKNESS OF LAMINATION = 0.5 mm

CORE FLUX DENSITY = 10 TESLA

VOLUME OF CORE = 7 m^3

MASS OF CORE = 50 kg

$$P_h = K_h f B^{1.6} m$$

$$= 2 \times 60 \times (10)^{1.6} \times 50$$

$$= 120 \times 39.8 \times 50$$

$$= 238864 \text{ WATT}$$

$$= 238.86 \text{ KW}$$

$$P_e = K_e f^2 t^2 B^2 V$$

$$= 3 \times (60)^2 \times (0.5 \times 10^{-3})^2 \times 10^2 \times 7$$

$$= 3 \times 3600 \times 0.25 \times 10^{-6} \times 100 \times 7$$

$$= 1890000 \times 10^{-6}$$

$$= 1.89 \text{ WATT}$$

PERCENTAGE VOLTAGE REGULATION

WHEN THE LOAD IS APPLIED ON A SELF-EXCITED SHUNT GENERATOR THE TERMINAL VOLTAGE WILL DROP DUE TO THREE EFFECTS. THESE ARE

(1) THE DROP IN THE RESISTANCE OF THE ARMATURE WINDING WHICH IS TERMED $I_a R_a$ DROP

(2) THE EFFECT OF THE ARMATURE FIELD ON THE MAIN FIELD WHICH WILL DECREASE THE EFFECTIVE FLUX

(3) THE RESULTANT DROP IN (1) & (2)

$$\text{PERCENTAGE REGULATION} = \frac{E_g - V_{FL}}{V_{FL}} \times 100$$

V_{FL} = FULL LOAD RATED VOLTAGE

E_g = NO LOAD OPEN CIRCUIT (GENERATED) VOLTAGE

pb V_{FL}

REGU

%.RE

pb A 7

OF 4%

SHUNT GENERATOR

EE EFFECTS. THESE

ATURE WINDING

THE MAIN FIELD

LUX

100

AGE

ULT

E

pb V_{FL} of A SHUNT GENERATOR IS 480 VOLT. WHAT IS PERCENTAGE REGULATION IF THE OPEN CIRCUIT VOLTAGE IS 510 V ?

$$\% \text{ REGULATION} = \frac{E_g - V_{FL}}{V_{FL}} \times 100$$

$$= \frac{510 - 480}{480} \times 100$$

$$= 6.85\%$$

---

pb A 75 kW 500 VOLT GENERATOR HAS A VOLTAGE REGULATION OF 4%. CALCULATE

(a) THE OPEN CIRCUIT VOLTAGE

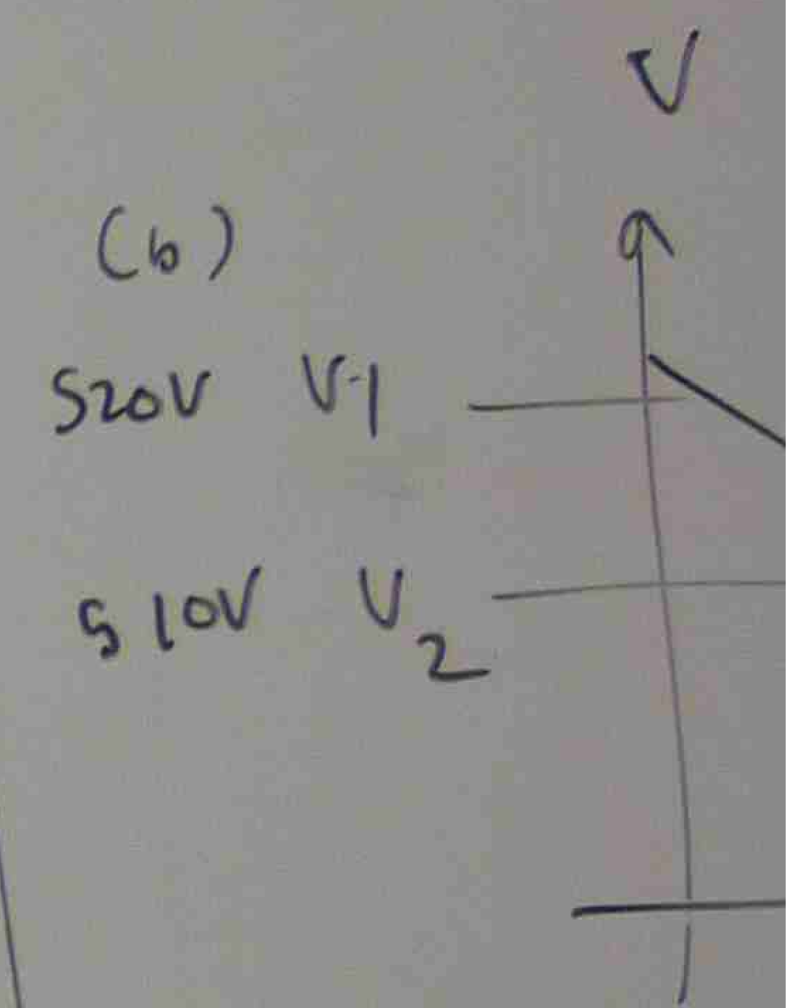
(b) ASSUMING THE VOLTAGE VARIES UNIFORMLY BETWEEN NO LOAD AND FULL LOAD CURRENT. CALCULATE THE kW OUTPUT OF A TERMINAL VOLTAGE OF 510.

(a) $\% \text{REG} =$

$4 =$

$\frac{4 \times 500}{100} + 5$

(b)



VOLT. WHAT IS PERCENTAGE
E IS 510V ?

(a) $\%REG = \dfrac{E_g - V_{FL}}{V_{FL}} \times 100$

$4 = \dfrac{E_g - 500}{500} \times 100$

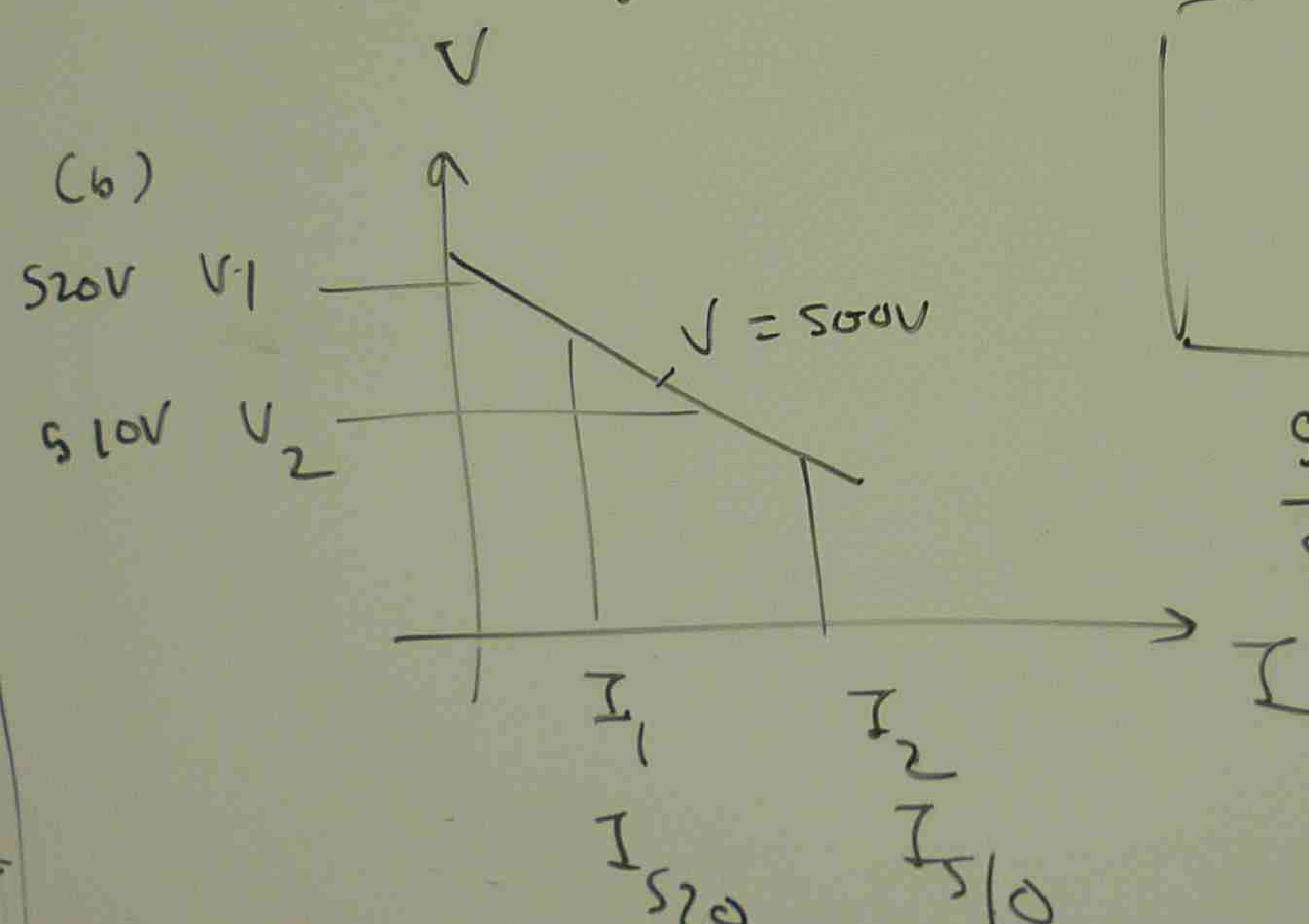
$\dfrac{4 \times 500}{100} + 500 = E_g$

$E_g = 520V$

AS A VOLTAGE REGULATION

RIES UNIFORMLY BETWEEN
URRENT.
UT OF A TERMINAL VOLTAGE

(b)



$$\boxed{\dfrac{V_1 - V_2}{V_1 - V} = \dfrac{I_2}{I_1}}$$

$\dfrac{520 - 510}{520 - 500} = \dfrac{I_{510}}{I_{520}}$

V_1 = NO LOAD VOLTAGE

V = FULL LOAD VOLTAGE

V_2 = ANY VOLTAGE

$\dfrac{10}{20} = \dfrac{I_{510}}{I_{520}}$

FULL LOAD CUR R GN

$\dfrac{10}{20} = \dfrac{I_{510}}{150}$

$I_{510} = 15$

OUTPUT =

$$\boxed{\frac{V_1 - V_2}{V_1 - V} = \frac{I_2}{I_1}}$$

$$\frac{520-510}{520-500} = \frac{I_{510}}{I_{520}}$$

V_1 = NO LOAD VOLTAGE

V = FULL LOAD VOLTAGE

V_2 = ANY VOLTAGE

$$\frac{10}{20} = \frac{I_{510}}{I_{520}}$$

FULL LOAD CURRENT => TERMINAL VOLTAGE 500V

NO LOAD VOLTAGE 520 V

$$= \frac{\text{POWER}}{\text{TERMINAL VOLTAGE}}$$

$$= \frac{75 \times 10^3}{500}$$

$$I_{520} = 150 \text{ Amp.}$$

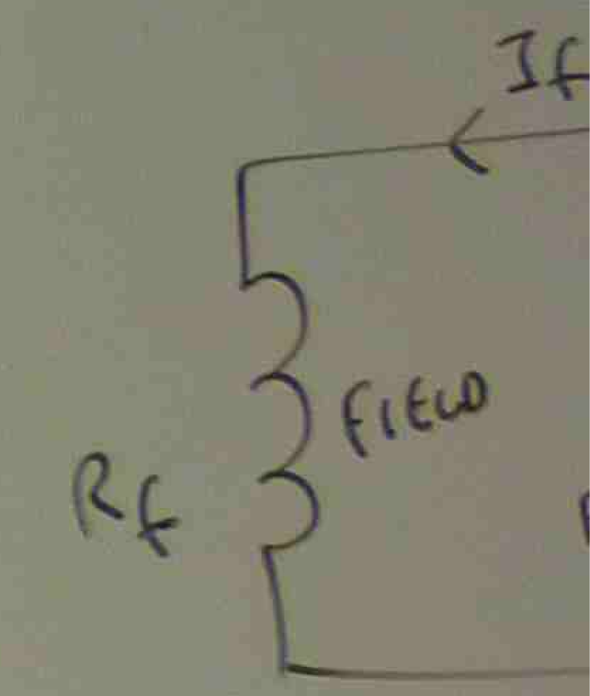
$$\frac{10}{20} = \frac{I_{510}}{150}$$

$$I_{510} = 150 \times \frac{10}{20} = 75 \text{ Amp.}$$

$$\text{OUTPUT} = V \times I = 510 \times 75 = 38250 \text{ W}$$

$$= 38.25 \text{ kW}$$

LOADING A

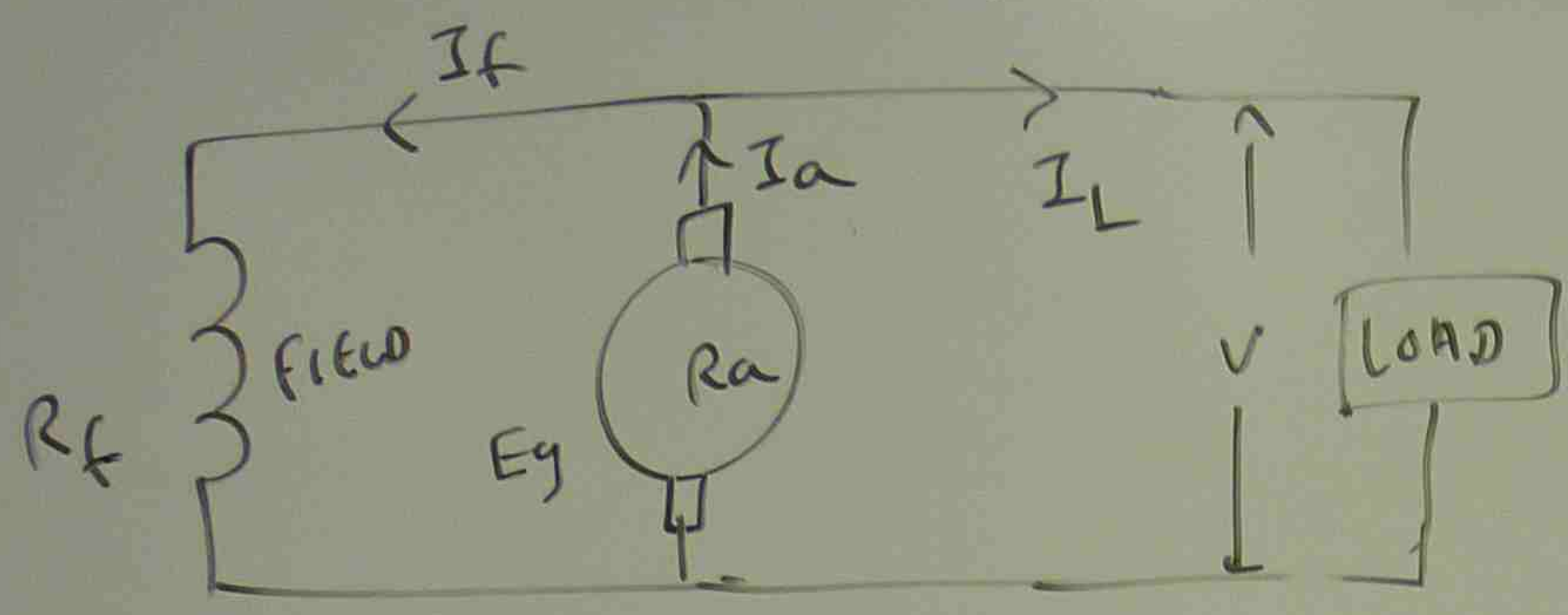


E_g

I

I

LOADING A GENERATOR



$$E_g = V + I_a R_a$$

$$I_a = I_L + I_f$$

$$I_f = \frac{V}{R_f}$$

GENERATED VOLTAGE EQUATION

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

E_g = GENERATED VOLTAGE (V)

ϕ = FLUX (Wb)

Z = NO. OF ARMATURE CONDUCTORS

N = SPEED (RPM)

P = NO. OF POLES

a = NO. OF ARMATURE PARALLEL PATHS

$a = m \times P$ LAP

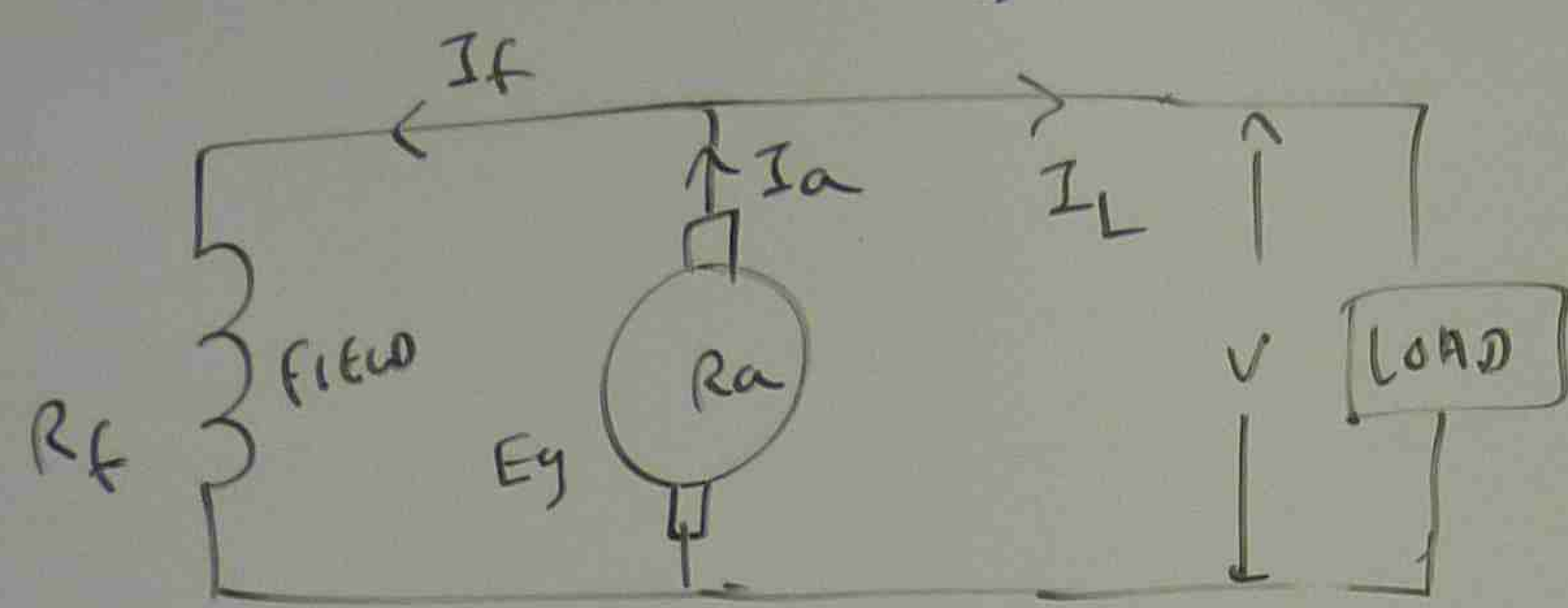
$m = 1$ SIMPLEX

$= 2$ DUPLEX

$= 3$ TRIPPLEX

$a = m \times 2$ WAVE

LOADING A GENERATOR



$$E_g = V + I_a R_a$$

$$I_a = I_L + I_f$$

$$I_f = \frac{V}{R_f}$$

GENERATED VOLTAGE EQUATION

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

E_g = GENERATED VOLTAGE (V)

ϕ = Flux (wb)

Z = NO. OF ARMATURE CONDUCTORS

N = SPEED (RPM)

P = NO. OF POLES

a = NO. OF ARMATURE PARALLEL PATHS

$a = m \times P$ LAP

m = 1 SIMPLEX
= 2 DUPLEX
= 3 TRIPPLEX

$a = m \times 2$ WAVE

POWER

TERMINAL VOLTAGE

$$\frac{75 \times 10^3}{500}$$

150 Amp.

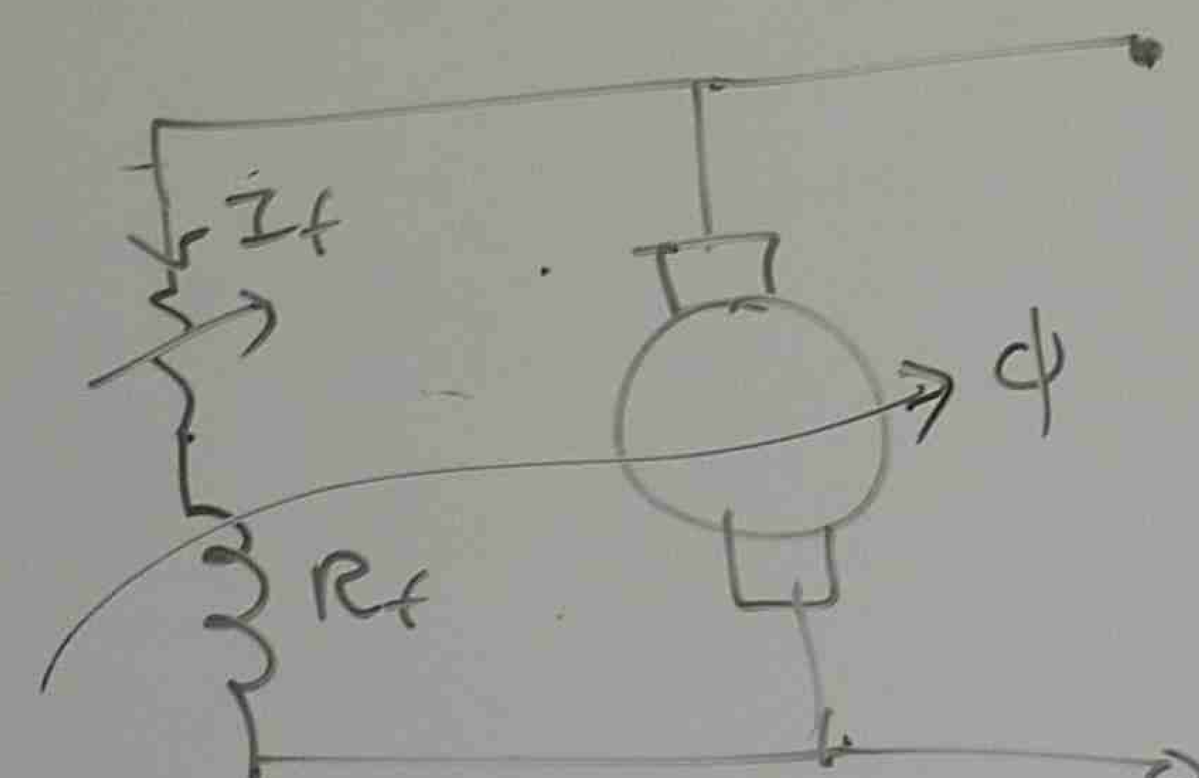
W

KW

TRANSFER FUNCTION OF SELF EXCITED MACHINE

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

ϕ = FIELD EXCITATION FLUX $\propto$ FIELD CURRENT (I_f)



BY ADJUSTING THE FIELD RHEOSTAT, FIELD EXCITATION CURRENT IS VARIED AND IT AFFECTS THE GENERATED VOLTAGE E_g.

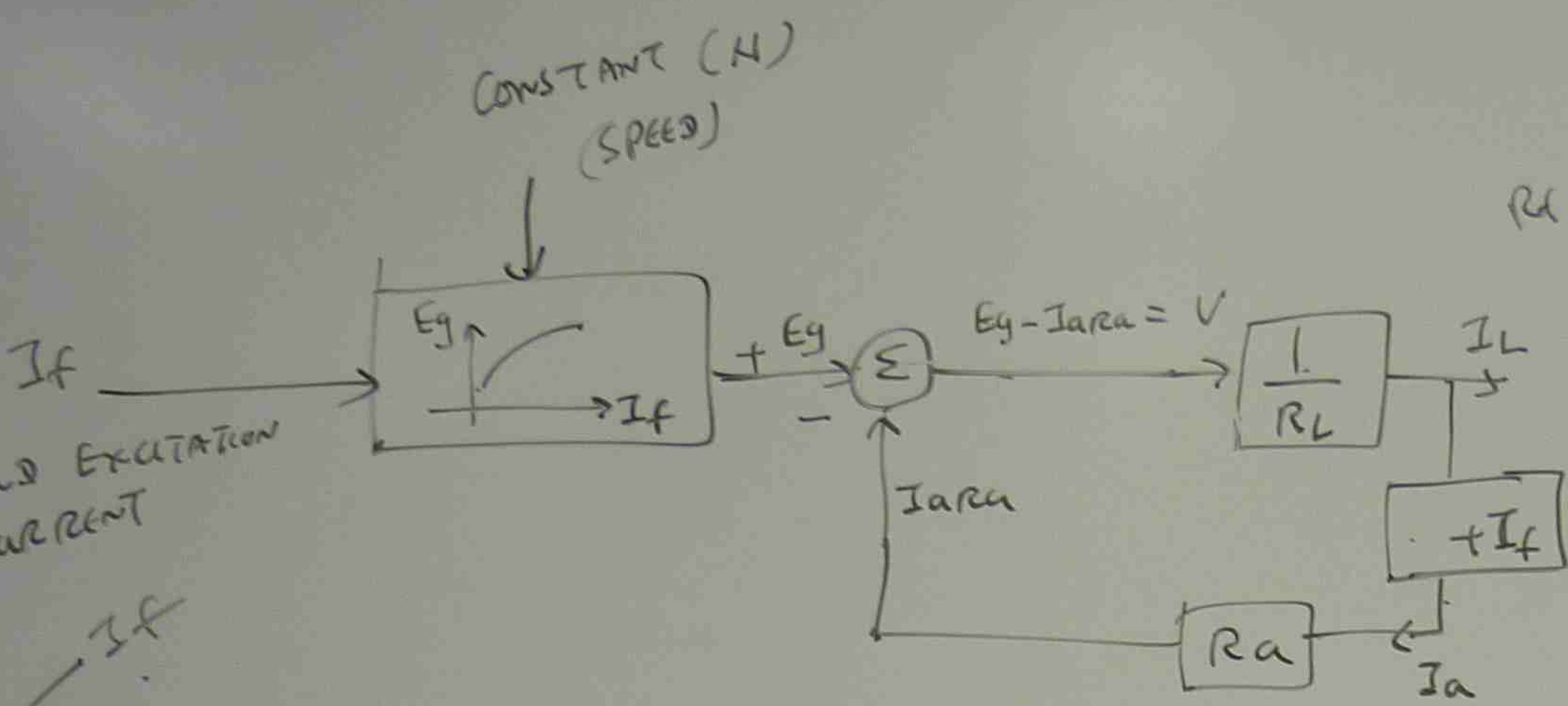
$I_f \longrightarrow$

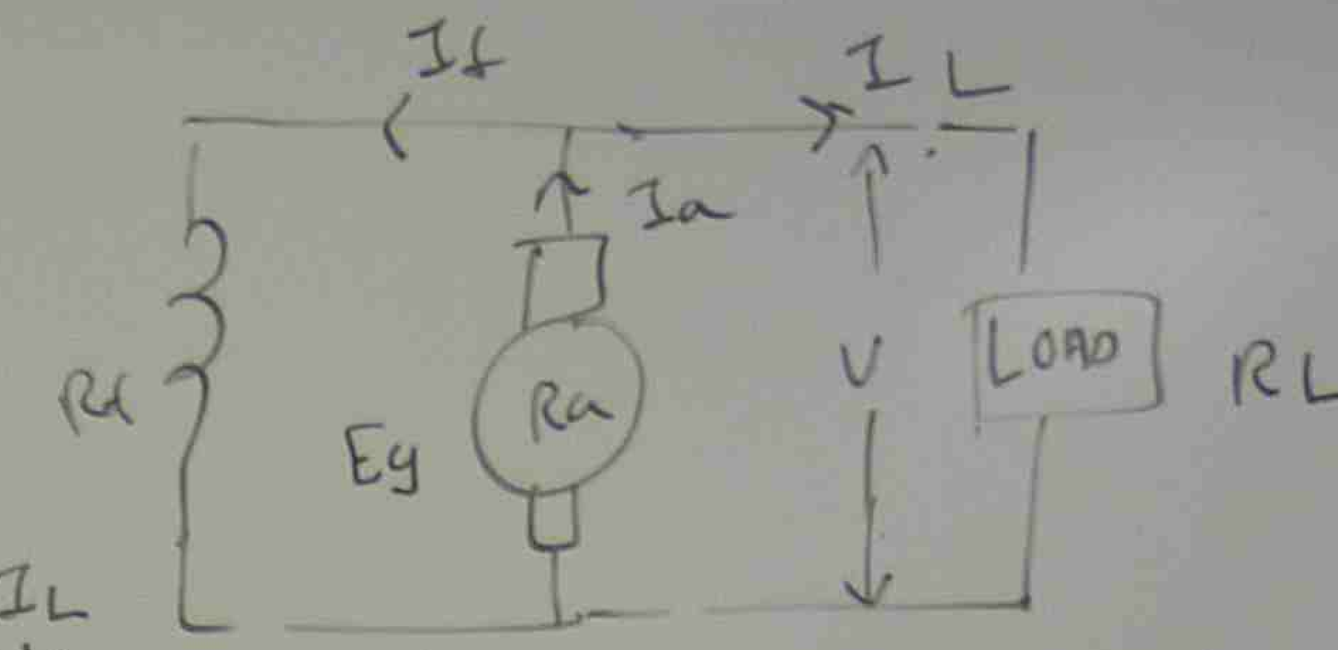
FIELD EXCITATION CURRENT

$$E_g = \frac{\overset{I_f}{\phi} Z N}{60} \times \frac{P}{a}$$

$I_f \uparrow \rightarrow \phi \uparrow \rightarrow E_g$

RENT





$$E_g = V + I_a R_a$$

$$E_g - I_a R_a = V$$

$$\frac{V}{R_L} = I_L$$

$$I_a = I_L + I_f$$

$$I_a = \frac{V}{R_L} + I_f$$

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

I_f

$$I_f \uparrow \rightarrow \phi \uparrow \rightarrow E_g \uparrow$$

TATION

NERATED

TRANSFER FUNCTION BLOCK DIAGRAM FOR SELF EXCITED GENERATOR

FROM THE TRANSFER FUNCTION,

(1) CHANGE OF FIELD EXCITATION CURRENT & SPEED AFFECTS E_g

(2) E_g IS RELATED TO TERMINAL VOLTAGE V

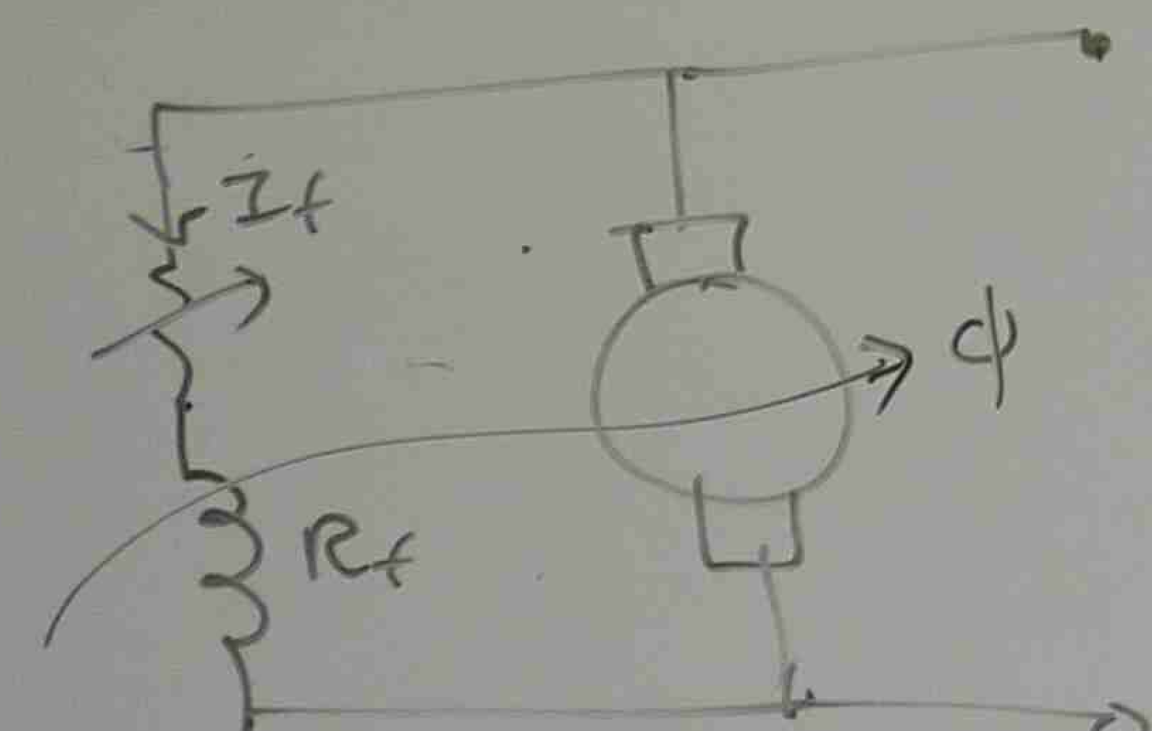
(3) TERMINAL VOLTAGE "V" IS RELATED TO LOAD CURRENT I_L AND " " ARMATURE CURRENT I_a

(4) $E_g - I_a R_a = V$

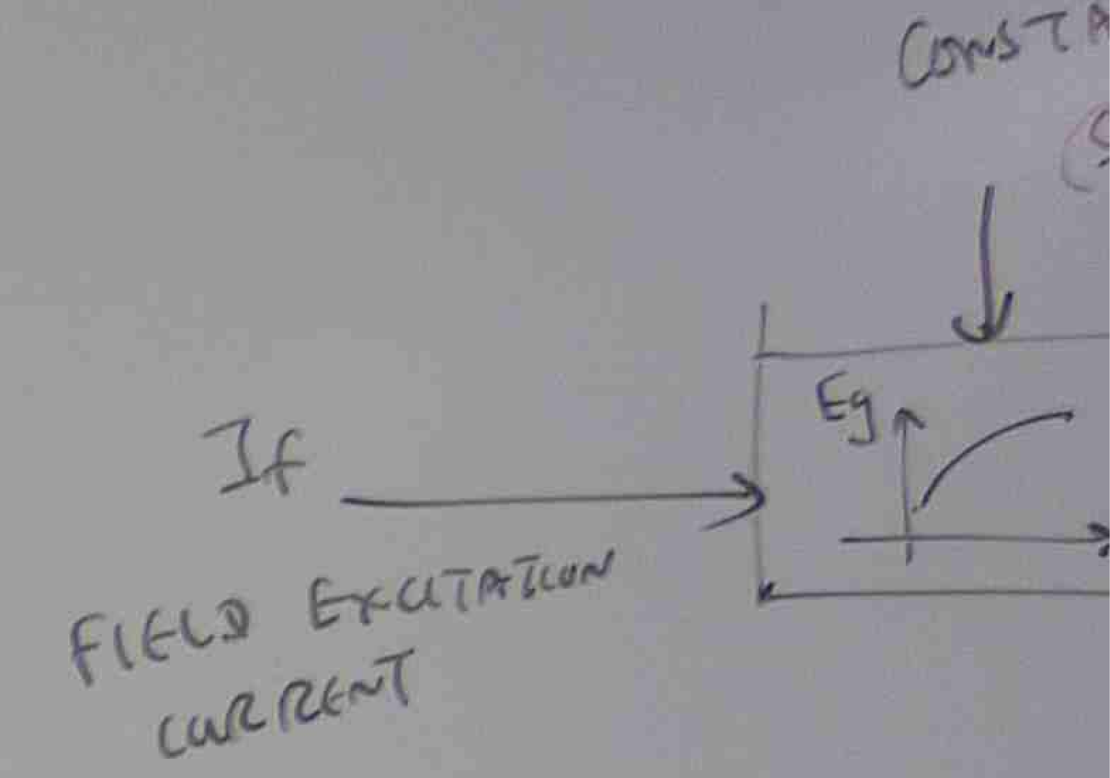
TRANSFER FUNCTION OF SELF EXCITED MACHINE

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

ϕ = FIELD EXCITATION FLUX $\propto$ FIELD CURRENT (I_f)



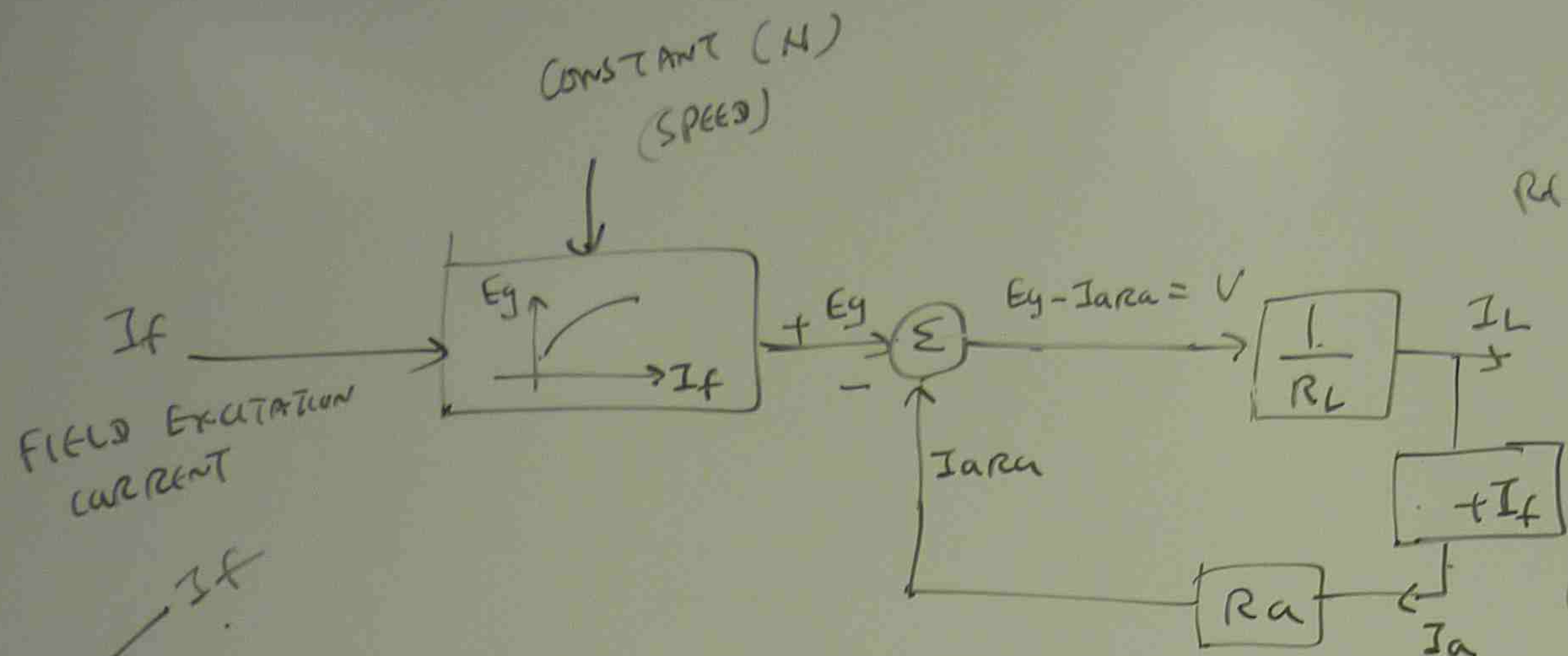
BY ADJUSTING THE FIELD RHEOSTAT, FIELD EXCITATION CURRENT IS VARIED AND IT AFFECTS THE GENERATED VOLTAGE E_g.

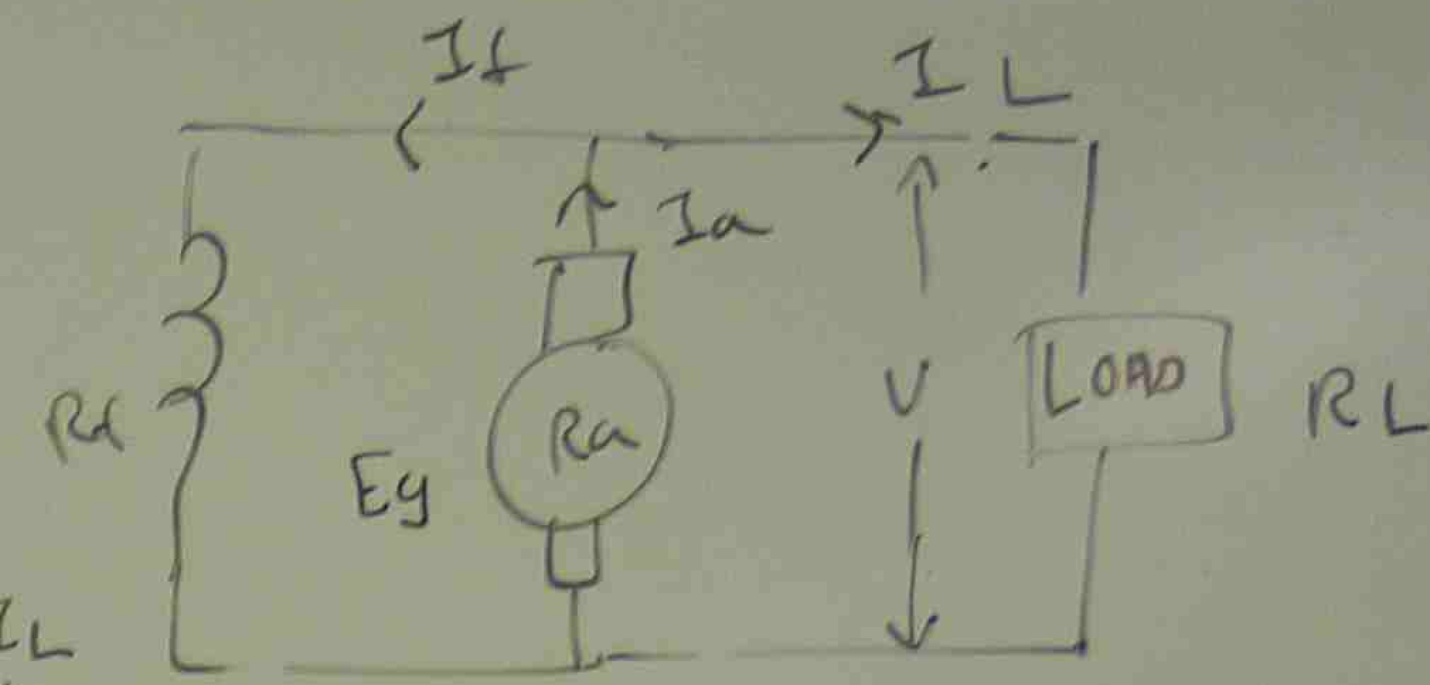


I_f

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

$I_f \uparrow \rightarrow \phi \uparrow \rightarrow E_g \uparrow$





$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

I_f

$$I_f \uparrow \rightarrow \phi \uparrow \rightarrow E_g \uparrow$$

TRANSFER FUNCTION
BLOCK DIAGRAM FOR
SELF EXCITED GENERATOR

$$E_g = V + I_a R_a$$

$$E_g - I_a R_a = V$$

$$\frac{V}{R_L} = I_L$$

$$I_a = I_L + I_f$$

$$I_a = \frac{V}{R_L} + I_f$$

FROM THE TRANSFER FUNCTION,

(1) CHANGE OF FIELD EXCITATION CURRENT & SPEED AFFECTS E_g

(2) E_g IS RELATED TO TERMINAL VOLTAGE V

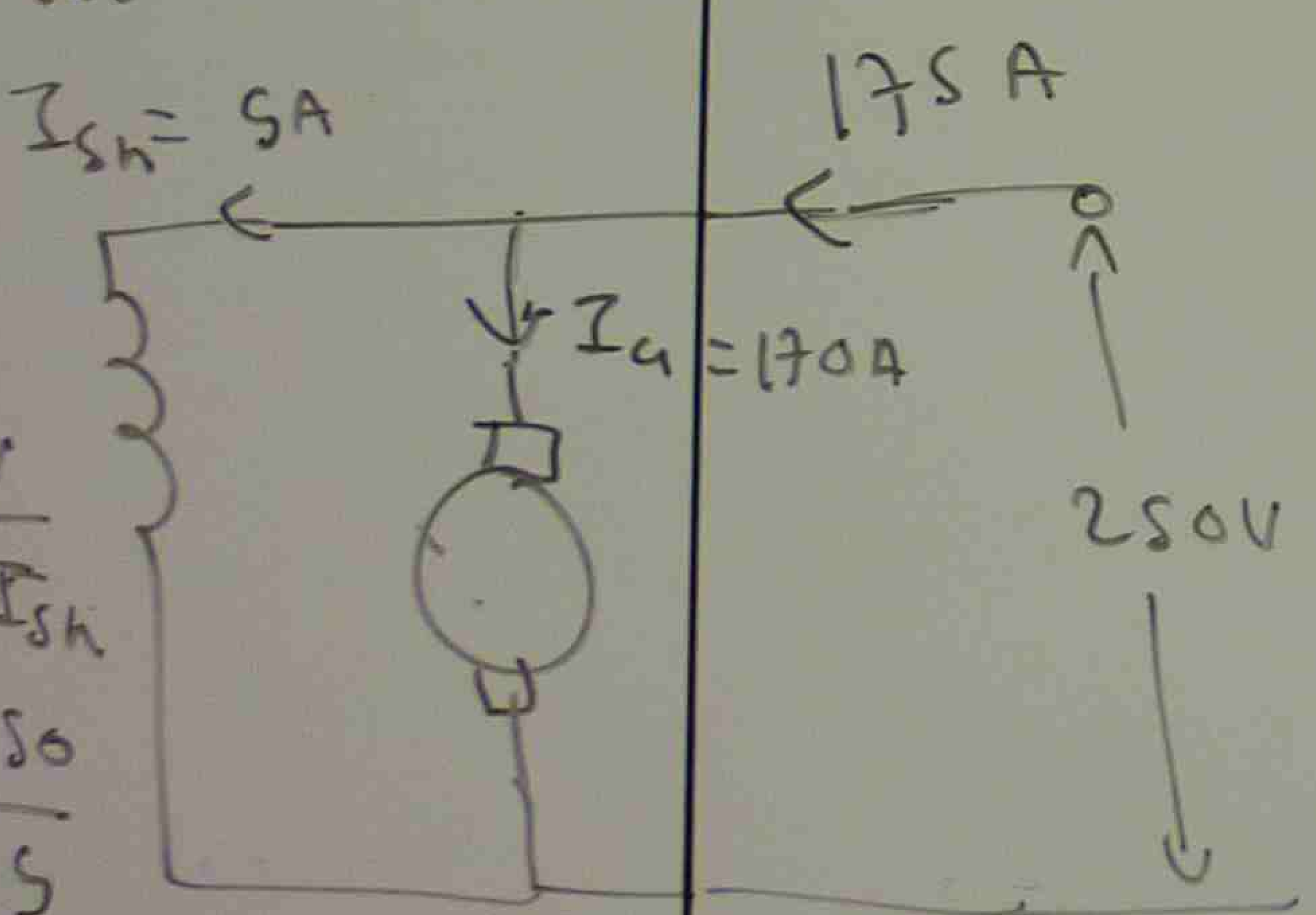
(3) TERMINAL VOLTAGE "V" IS RELATED TO LOAD CURRENT I_L AND ARMATURE CURRENT "I_a"

(4) $E_g - I_aR_a = V$

P2) A 50 HP 250 V 1200 RPM SHUNT DC MOTOR HAS A RATED ARMATURE CURRENT OF 170 Amp AND RATED FIELD CURRENT OF 5 A. WHEN THE ROTOR IS BLOCKED, THE ARMATURE VOLTAGE 10V PRODUCES A 170 A CURRENT FLOW AND FIELD VOLTAGE 250V PRODUCES A FIELD CURRENT FLOW OF 5A. AT NO LOAD WITH TERMINAL VOLTAGE EQUAL TO 240V, THE ARMATURE CURRENT IS EQUAL TO 13.2 Amp, FIELD CURRENT 4.8A. MOTOR SPEED IS 1150 RPM.

(a) HOW MUCH POWER IS OUTPUT FROM THIS MOTOR AT RATED CONDITION

(b) MOTOR EFFICIENCY



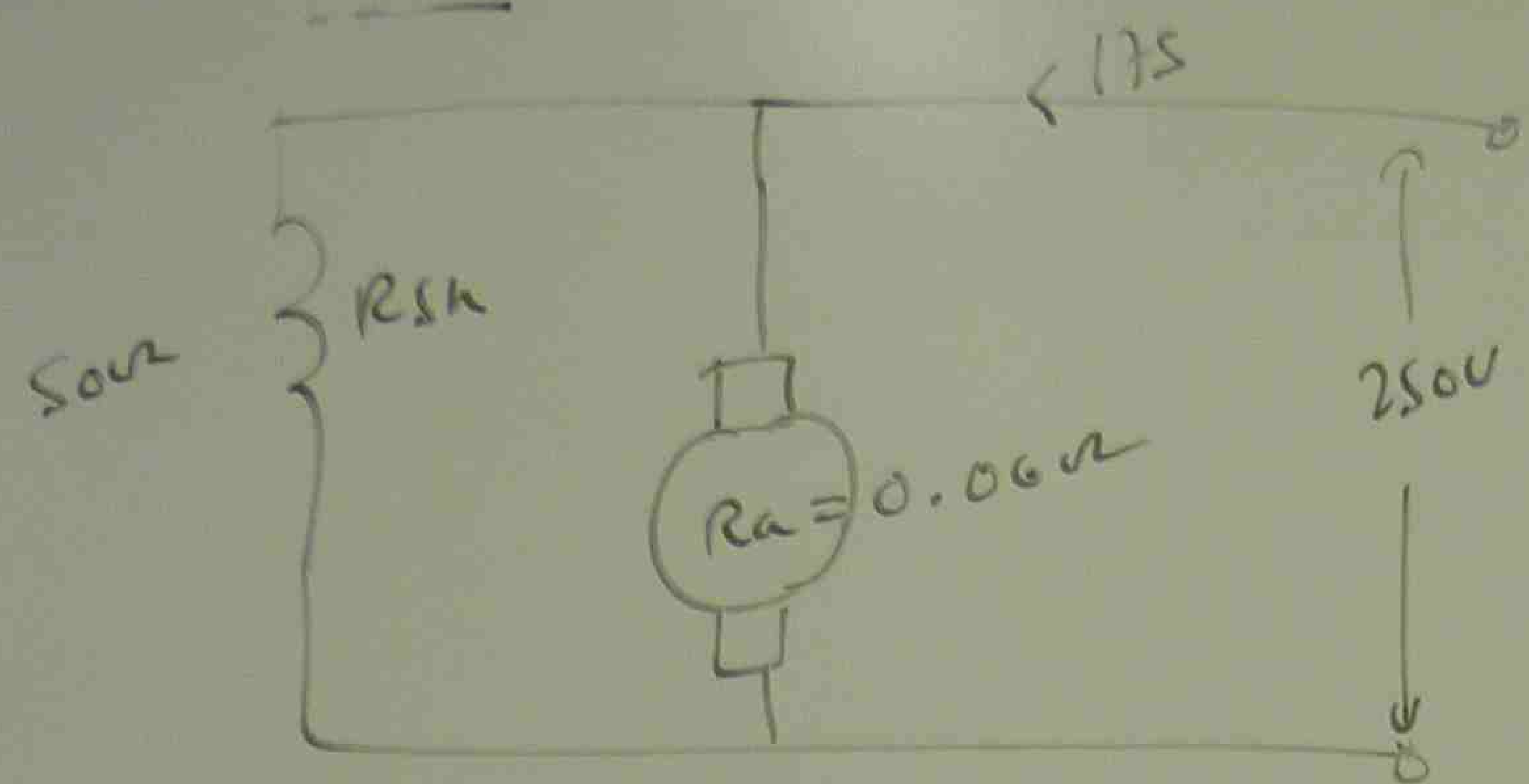
$$R_{sh} = \frac{V}{I_{sh}} = \frac{250}{5} = 50\Omega$$

BLOCKED ROTOR EQUIVALENT CIRCUIT

$$R_a = \frac{V}{I} = \frac{10}{170} = 0.06\Omega$$

$$= \frac{10}{170}$$

$$= 0.06\Omega$$



NO LOAD

ALL POWER LOSSES = ROTATIONAL LOSSES.

ROTATIONAL LOSS = TERMINAL VOLTAGE AT NO LOAD × NO LOAD ARMATURE CURRENT

$= 240 \times 13.2$

$= 3168 W$

RATED CONDITION POWER OUTPUT

OUTPUT POWER AT RATED CONDITION = IN

COPPER LOSS = $I_a^2 Ra + I$

$= (170)^2 \times 0.0$

INPUT POWER = $VI =$

OUTPUT POWER = 437

$= 39$

EFFICIENCY = $\frac{\text{OUTPUT}}{\text{INPUT}} \times 10$

RATED CONDITION POWER OUTPUT

OUTPUT POWER AT RATED CONDITION = INPUT POWER — (COPPER LOSS + ROTATIONAL LOSSES)

COPPER LOSS = $I_a^2 R_a + I_{sh}^2 R_{sh}$

$= (170)^2 \times 0.06 + (5)^2 \times 50 = 2984$ WATT

INPUT POWER = $VI = 250 \times 175 = 43750$ WATT

OUTPUT POWER = $43750 - (2984 + 3168)$

$= 39593$ W

EFFICIENCY = $\frac{\text{OUTPUT}}{\text{INPUT}} \times 100 = \frac{39593}{43750} \times 100 = 90.5\%$

× NO LOAD ARMATURE CURRENT

13.2

W

Pb A SIX POLE WAVE WOUND DC GENERATOR HAS 410 ACTIVE CONDUCTORS. IF THE GENERATOR IS DRIVEN AT 750 RPM, CALCULATE THE OPEN CIRCUIT VOLTAGE IF USEFUL FLUX PER POLE IS 0.03 wb.

$P = 6$ WAVE , $Z = 410$

$N = 750$ RPM $E_g = ?$

$\phi = 0.03$ wb

$a = 2 \times m$ WAVE

$= 2 \times 1 = 2$

a = NO. OF ARMATURE PARALLEL PATHS.

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a}$$

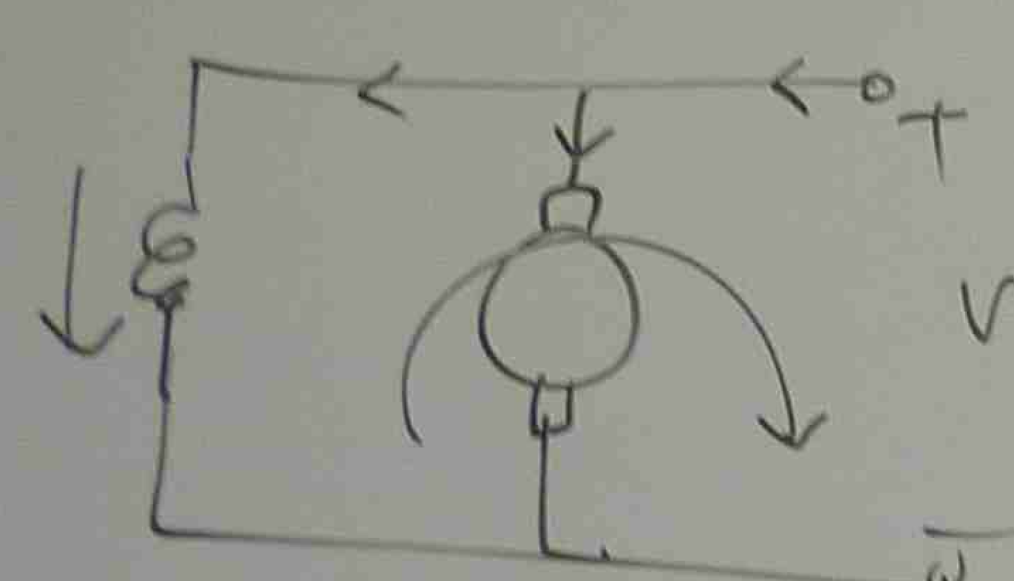
$$= \frac{0.03 \times 410 \times 750}{60} \times \frac{6}{2}$$

$=$

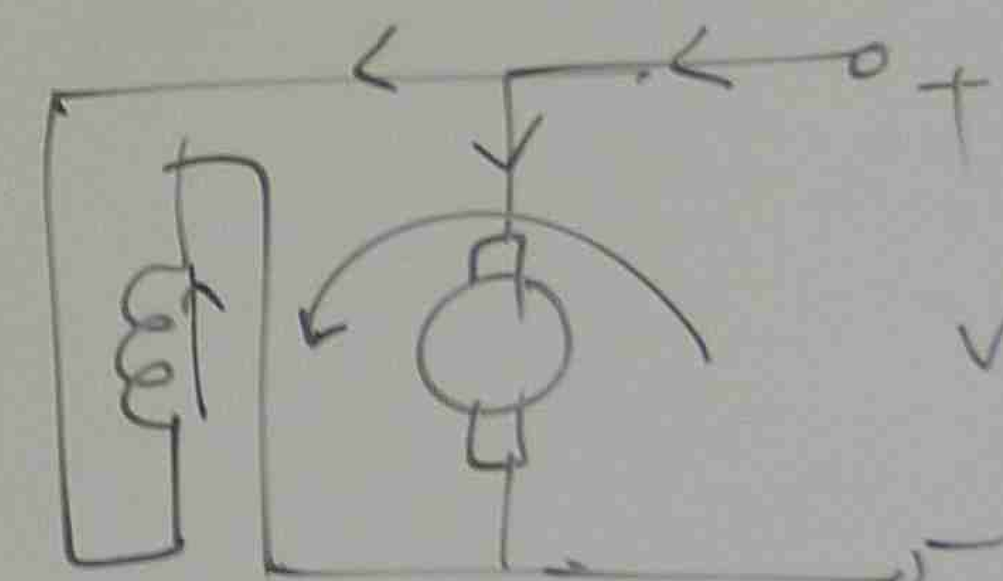
EFFECT OF CHANGING FLUX AND SPEED ON VOLTAGE

$$E_g \propto \phi N$$

$$\frac{E_{g1}}{E_{g2}} = \frac{\phi_1 N_1}{\phi_2 N_2}$$



DC MOTOR



BY CHANGING THE FIELD CONNECTION, MOTOR ROTATION DIRECTION CAN BE REVERSED.

pb MOTOR PA

$R_a = 0.3\Omega$,

CALCULATE

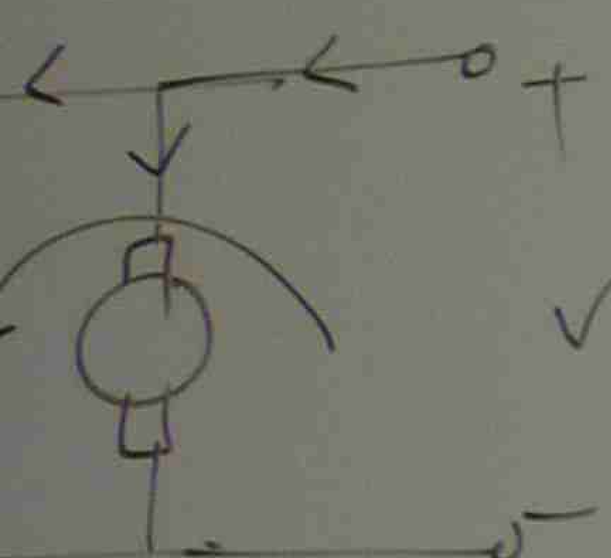
(a)

WATT = 2

$3.75 \times 10^3 =$

T = 3

K AND SPEED ON VOLTAGE



CONNECTION,

CAN BE

PB MOTOR PARTICULARS → 3.75 KW, 230 V, 10 Amp, 1750 RPM

$R_a = 0.3\,\Omega$, BRUSH DROP = 2V ON LOAD.

CALCULATE

(a) FULL LOAD TORQUE

(b) INITIAL RUSH OF ARMATURE CURRENT AND CORRESPONDING TORQUE AT THE INSTANT THE FIELD RESISTANCE IS INCREASING TO REDUCE THE FIELD FLUX TO 0.96 OF ORIGINAL VALUE

(c) FINAL ARMATURE CURRENT, SPEED AND POWER CONSUMPTION

(a)

$$\text{WATT} = \frac{2\pi N T}{60}$$

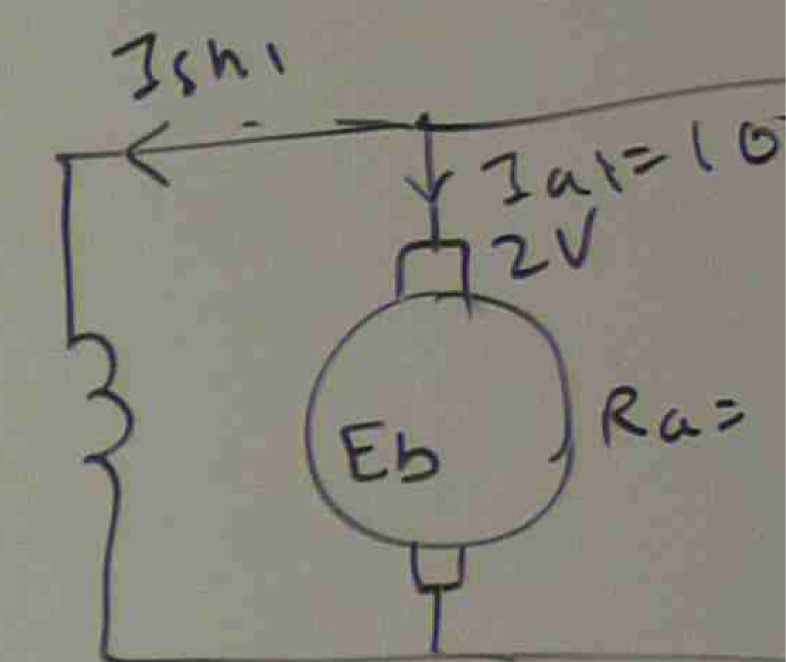
$$3.75\times10^3 = \frac{2\times3.1416\times1750\times T}{60}$$

$$T = \frac{3.75\times10^3\times60}{2\times3.1416\times1780} = 20.47\ \text{N-m}$$

(b)

$T =$

$\dfrac{T_1}{T_2} =$



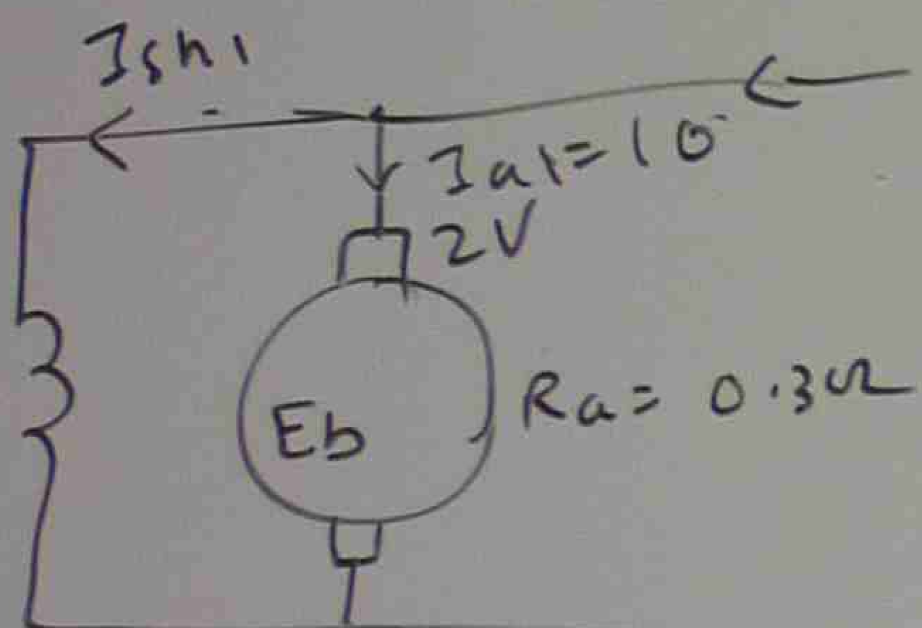
$I_{sh_1} =$

FIELD FLUX

(a)

$T = K\phi I_a$ MOTOR TORQUE

$$\frac{T_1}{T_2} = \frac{\phi_1 I_{a1}}{\phi_2 I_{a2}}$$



$$I_{FL} = \frac{\text{POWER}}{\text{VOLTAGE}}$$

$$= \frac{3750}{230}$$

$$= 16.3 \text{ Amp.}$$

$I_{sh_1} = 16.3 - 10 = 6.3$ Amp.

$$R_{BRUSH} = \frac{2V}{I_a} = \frac{2}{10} = 0.2\Omega$$

FIELD FLUX IS REDUCED

$$E_{b_1} = V - (I_a R_a + \text{BRUSH DROP})$$

$$= 230 - (10 \times 0.3 + 2)$$

$$= 225V$$

$$\frac{E_{b1}}{E_{b2}} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$$\frac{225}{E_{b2}} = \frac{\phi_1 \times \cancel{N_1}}{0.96\phi_1 \times \cancel{N_2}}$$

$$E_{b2} = 0.96 \times 225$$

$$= 216V$$

$$E_{b2} = V - (I_{a2} R_a + \text{BRUSH DROP})$$

$$216 = 230 - (I_{a2} \times 3 + I_{a2} \times R_b)$$

$$216 = 230 - (I_{a2} \times 0.3 + I_{a2} \times 0.2)$$

$$0.5\, I_{a2} = 230 - 216 = 14$$

$$I_{a2} = \frac{14}{0.5} = 28 \text{ Amp.}$$

$$\frac{T_1}{T_2} = \frac{\phi_1 I_{a1}}{\phi_2 I_{a2}}$$

$$\frac{20.47}{T_2} = \frac{\phi_1}{0.96\phi_1} \times \frac{10}{28}$$

$$T_2 = \frac{20.47 \times 0.96 \times 28}{10}$$

$$= 55 \text{ N-m}$$

$$\frac{E_{b1}}{E_{b2}} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$$\frac{225}{216} = \frac{\phi_1 \times 1750}{0.96\phi_1 \times N_2}$$

$$N_2 = \frac{216 \times 1750}{225 \times 0.96}$$

$$= 1750 \text{ RPM}$$

$$P = 2\pi N_2 T$$

$$= \frac{2 \times 3.1416 \times 1750 \times 55}{60}$$

$$= 10079 \text{ WATT}$$

$$= 10.079 \text{ kW}$$

mp.

7.46 KW, 230V, 1750 RPM SHUNT MOTOR.

ARMATURE RESISTANCE 0.35Ω. SHUNT FIELD RESISTANCE 62.2Ω.

(a) NO LOAD CURRENT IS 7.7 AMP. FULL LOAD EFFICIENCY 86%. BRUSH DROP 3 VOLT AT FULL LOAD

CALCULATE % REGULATION

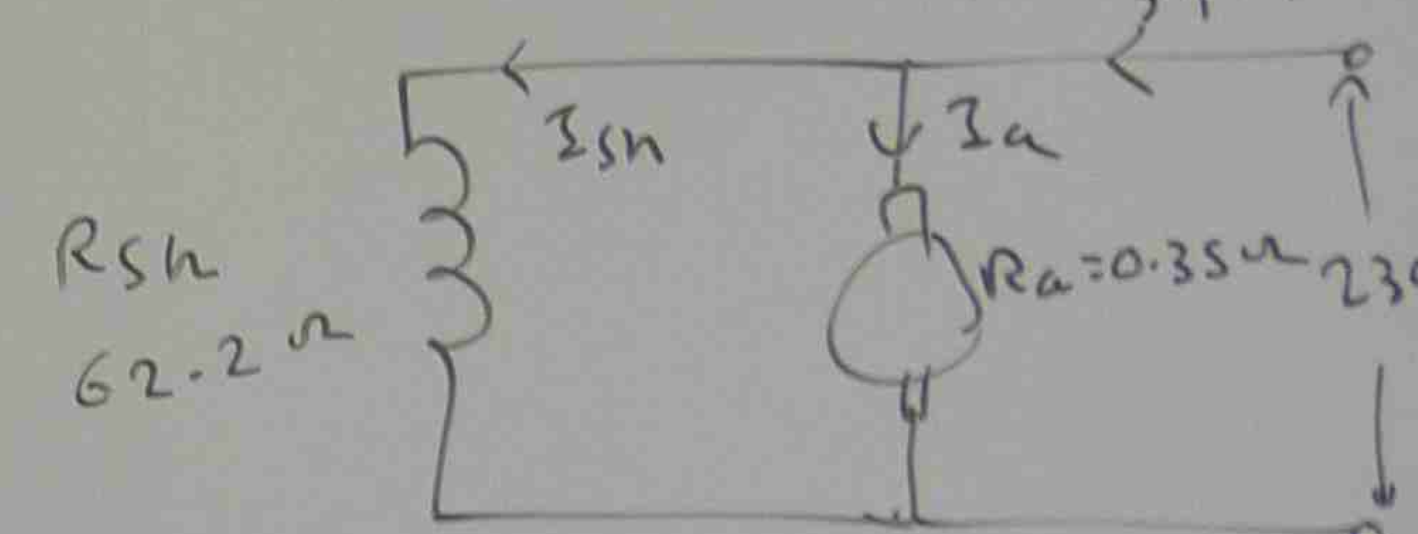
(b) A 2.65Ω RESISTANCE IS PLACED IN SERIES WITH ARMATURE CIRCUIT, CALCULATE NEW SPEED, % REGULATION, % POWER LOSS IN SERIES RESISTANCE IN RESPECT OF TOTAL POWER INPUT.

(a) $$I_{FL} = \frac{\text{OUTPUT POWER}}{\text{VOLTAGE} \times \text{EFFICIENCY}}$$

$$= \frac{7.46 \times 10^3}{230 \times 0.86}$$

$$= 37.7 \text{ Amp.}$$

37.7 Amp = IFL



$$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{62.2} = 3.7 \text{ Amp.}$$

$$I_a = I_{FL} - I_{sh} = 37.7 - 3.7 = 34 \text{ Amp}$$

$N_{FL} = 1750\ RPM$ $\quad I_{aFL} = 34\ Amp$

$N_{NL} = ?$

$I_{aNL} = I_{NL} - I_{sh\,NL}$

$= 7.7 - 3.7$

$= 4\ Amp.$

$$\frac{E_{b1}}{E_{b2}} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$$\frac{V - (I_{aFL} \times R_a + \text{BRUSH DROP})}{V - (I_{aNL} R_a + \text{BRUSH DROP})} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$\phi_1 = \phi_2$

$$\frac{230 - (34 \times 0.35 + 3)}{230 - (4 \times 0.35 + 3)} = \frac{\cancel{\phi_1} N_1}{\cancel{\phi_2} N_2}$$

$$\frac{215.1}{225.6} = \frac{1750}{N_2}$$

$$N_2 = 1750 \times \frac{225.6}{215.1} = 1850\ RPM$$

$N_2 \Updownarrow N_{NL}$

$$\%\ \text{SPEED REGULATION} = \frac{N_{NL} - N_{FL}}{N_{FL}} \times 100$$

$$= \frac{1850 - 1750}{1750} \times 100$$

$= 5.7\%$

= I_{FL}

Amp.

3.7 = 34 Amp

(b)

(b)

$$E_{b_3} = V - (I_a R_a + \text{BRUSH DROP})$$

$$= 230 - [34(0.35 + 2.65) + 3]$$

$$= 125\text{V}$$

$$\frac{E_{b2}}{E_{b3}} = \frac{\cancel{\phi_2} N_2}{\cancel{\phi_3} N_3}$$

$$\frac{225.6}{125} = \frac{1850}{N_3}$$

$$N_3 = \frac{1850 \times 125}{225}$$

$$= 1020\text{RPM}$$

$$\%\ \text{REG} = \frac{N_{NL} - N_3}{N_3} \times 100$$

$$= \frac{1850 - 1020}{1020} \times 100$$

$$= 81.3\%$$

$$2.65\Omega \text{ power loss} = I_a^2 \times 2.65$$

$$= 34^2 \times 2.65 = 3060\text{W}$$

$$\%\ \text{of power input} = \frac{3060}{V_T \times I_{FL}} \times 100$$

$$= \frac{3060}{230 \times 37.7} \times 100 = 39.2\%$$

Pb — 7.46 kW, 230V, 1750 RPM SHUNT MOTOR.

ARMATURE RESISTANCE 0.35Ω. SHUNT FIELD RESISTANCE 62.2Ω.

(a) NO LOAD CURRENT IS 7.7 amp. FULL LOAD EFFICIENCY 86 %. BRUSH DROP 3 VOLT AT FULL LOAD

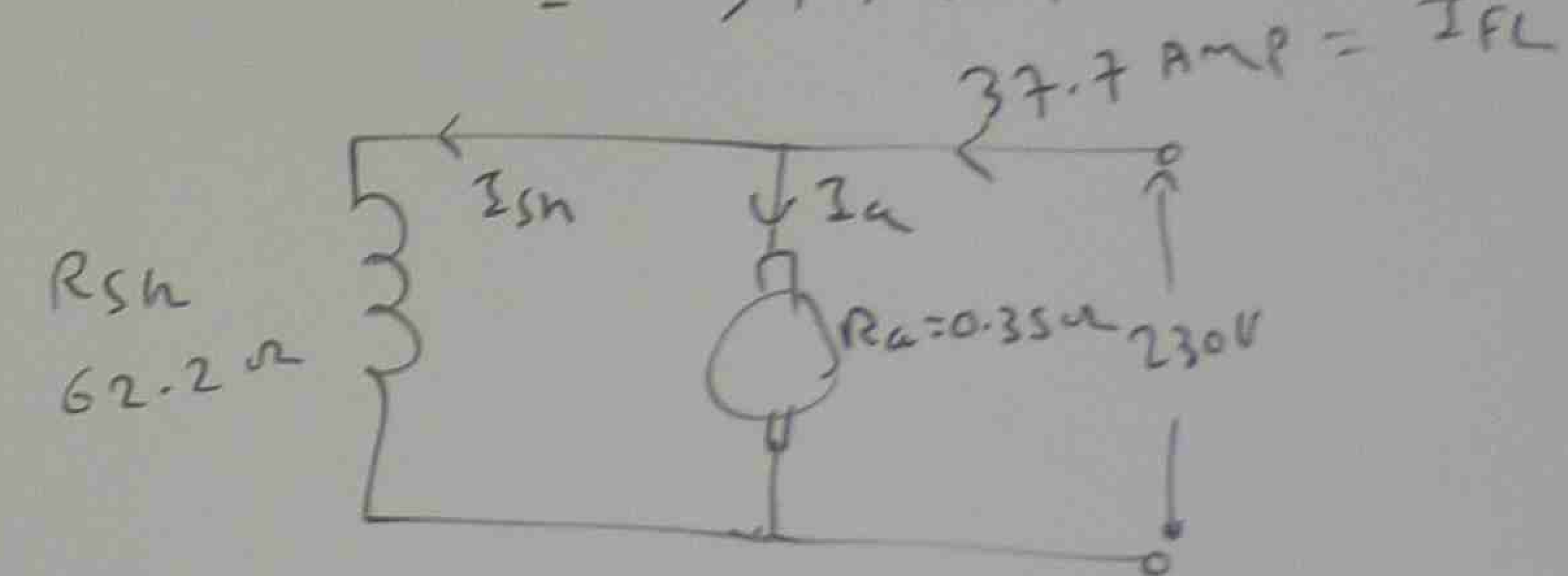
CALCULATE % REGULATION

(b) A 2.65Ω RESISTANCE IS PLACED IN SERIES WITH ARMATURE CIRCUIT, CALCULATE NEW SPEED, % REGULATION, % POWER LOSS IN SERIES RESISTANCE IN RESPECT OF TOTAL POWER INPUT.

(a) $$I_{FL} = \frac{\text{OUTPUT POWER}}{\text{VOLTAGE} \times \text{EFFICIENCY}}$$

$$= \frac{7.46 \times 10^3}{230 \times 0.86}$$

$$= 37.7 \text{ Amp.}$$



$$I_{sh} = \frac{V}{R_{sh}} = \frac{230}{62.2} = 3.7 \text{ Amp.}$$

$$I_a = I_{FL} - I_{sh} = 37.7 - 3.7 = 34 \text{ Amp}$$

$N_{FL} = 1750\ RPM$ $\quad$ $I_{aFL} = 34\ Amp$

$N_{NL} = ?$ $\quad$ $I_{aNL} = I_{NL} - I_{sh\,NL}$

$= 7.7 - 3.7$

$= 4\ Amp.$

$$\frac{E_{b1}}{E_{b2}} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$$\frac{V - (I_{aFL} R_a + \text{BRUSH DROP})}{V - (I_{aNL} R_a + \text{BRUSH DROP})} = \frac{\phi_1 N_1}{\phi_2 N_2}$$

$\phi_1 = \phi_2$

$$\frac{230 - (34 \times 0.35 + 3)}{230 - (4 \times 0.35 + 3)} = \frac{\cancel{\phi_1} N_1}{\cancel{\phi_2} N_2}$$

$$\frac{215.1}{225.6} = \frac{1750}{N_2}$$

$$N_2 = \frac{1750 \times 225.6}{215.1} = 1850\ RPM$$

$N_2 \updownarrow N_{NL}$

$$\%\ \text{SPEED REGULATION} = \frac{N_{NL} - N_{FL}}{N_{FL}} \times 100$$

$$= \frac{1850 - 1750}{1750} \times 100$$

$= 5.7\%$

$.7\ Amp = I_{FL}$

$= 3.7\ Amp.$

$37.7 - 3.7 = 34\ Amp$

(b)

(b)

$$E_{b_3} = V - (I_a R_a + \text{BRUSH DROP})$$

$$= 230 - [34(0.35 + 2.65) + 3]$$

$$= 125\,V$$

$$\frac{E_{b2}}{E_{b_3}} = \frac{\cancel{\phi_2} N_2}{\cancel{\phi_3} N_3}$$

$$\frac{225.6}{125} = \frac{1850}{N_3}$$

$$N_3 = \frac{1850 \times 125}{225}$$

$$= 1020\,RPM$$

$$\%\,REG = \frac{N_{NL} - N_3}{N_3} \times 100$$

$$= \frac{1850 - 1020}{1020} \times 100$$

$$= 81.3\%$$

$$2.65\,\Omega \text{ power loss} = I_a^2 \times 2.65$$

$$= 34^2 \times 2.65 = 3060\,W$$

$$\%\text{ of power input} = \frac{3060}{V_T \times I_{FL}} \times 100$$

$$= \frac{3060}{230 \times 37.7} \times 100 = 35.2\%$$

REMS

(1)

REVISION (PART - 1 FOR TEST 1)

1. A MOTOR HAS A COMBINED MOMENT OF INERTIA $10\ N\text{-}m\ s^2$ AND INITIAL VELOCITY 200 RAD/S. IF THE TORQUE PRODUCED BY THE MOTOR IS INCREASED BY 50 N-m

CALCULATE (a) THE TIME FOR THE SPEED TO REACH 300 RAD/S

(b) THE FINAL SPEED IF THE TORQUE WAS MAINTAINED FOR 10 SEC

(c) THE TORQUE INCREASE NECESSARY TO OBTAIN AN INCREASE OF 50 RAD/S IN 25 SEC.

(a) $\omega_2 = \omega_1 + \alpha t$

ω_2 = FINAL ANGULAR VELOCITY

ω_1 = INITIAL ANGULAR VELOCITY

α = ANGULAR ACCELERATION

t = TIME

$300 = 200 + 5 \times t$

$T = I\alpha$

T = TORQUE, I = MOMENT OF INERTIA

$50 = 10 \times \alpha$

$\alpha = \frac{50}{10} = 5$

$t = \frac{300-200}{5} = 20\ \text{Sec}$

9-2%.

REVISION (PART-1 FOR TEST 1)

① A MOTOR HAS A COMBINED MOMENT OF INERTIA 10 N-m s^2 AND INITIAL VELOCITY 200 RAD/S. IF THE TORQUE PRODUCED BY THE MOTOR IS INCREASED BY 50 N-m

CALCULATE (a) THE TIME FOR THE SPEED TO REACH 300 RAD/S

(b) THE FINAL SPEED IF THE TORQUE WAS MAINTAINED FOR 10 SEC

(c) THE TORQUE INCREASE NECESSARY TO OBTAIN AN INCREASE OF 50 RAD/S IN 25 SEC.

(a) $\omega_2 = \omega_1 + \alpha t$

ω_2 = FINAL ANGULAR VELOCITY

ω_1 = INITIAL ANGULAR VELOCITY

α = ANGULAR ACCELERATION

t = TIME

$300 = 200 + 5 \times t$

$T = I\alpha$

T = TORQUE, I = MOMENT OF INERTIA

$50 = 10 \times \alpha$

$\alpha = \frac{50}{10} = 5$

$t = \frac{300-200}{5} = 20\,\text{Sec}$

(b) $\omega_2 = \omega_1 + \alpha t$

$= 200 + 5 \times 10$

$= 250$ rad/s

(c) $\alpha = \dfrac{\omega}{t} = \dfrac{50}{25} = 2$ rad/s^2

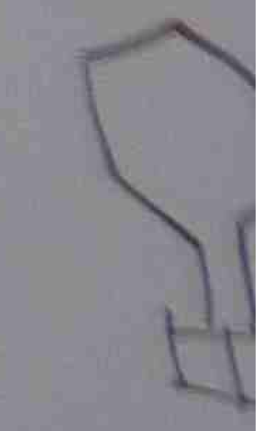
$T = I \alpha$

$= 10 \times 2 = 20$ N-m

pb

pb 3

LAP



ARE NOT
APPROPRIATE
FOOTWEAR
IN THIS BUILDING

Pb 2

EXPLAIN MAIN POLE AND INTERPOLE

MAIN POLE

MAIN POLE IS THE POLE WHICH PRODUCES THE MAIN MAGNETIC FLUX NECESSARY FOR MACHINE OPERATION

INTERPOLE

INTERPOLES ARE THE MINOR POLES BETWEEN MAIN POLES TO IMPROVE COMMUTATION.

Pb 3

CALCULATE THE COMMUTATOR BAR PITCH FOR THE FOLLOWING SIMPLEX WAVE WOUND ARMATURE, 4 POLES.

(a) 81 BARS (b) 131 BARS (c) 171 BARS

(a) $Y_c = \frac{c \pm m}{P/2} = \frac{81 \pm 1}{4/2} = \frac{81 \pm 1}{2} = \frac{82}{2}$ (or) $\frac{80}{2}$

$= 41$ (or) 40

(b) $Y_c = \frac{131 \pm 1}{4/2} = \frac{132}{2}$ (or) $\frac{130}{2} = 66$ (or) 65

(c) $Y_c = \frac{171 \pm 1}{4/2} = \frac{172}{2}$ (or) $\frac{170}{2} = 86$ (or) 85

LAP

COMMUTATOR BAR PITCH $= \frac{S}{P}$

S = SLOT NO.

WAVE

Y_c

COMMUTATOR BAR PITCH $= \frac{C \pm m}{P/2}$

$+$ = PROGRESSIVE

$-$ = RETROGRESSIVE

C = NO. OF COMMUTATOR BAR

m = PLEX NO. SIMPLEX m = 1

DUPLEX m = 2

DC MACHINE TEST (2) REVISION

① A MOTOR HAS A COMBINED MOMENT OF INERTIA OF $10\ \text{N-m}^2$ AND AN INITIAL VELOCITY OF 200 RADIANS PER SECOND. IF THE TORQUE PRODUCED BY THE MOTOR WAS INCREASED BY 50 N-m CALCULATE

(a) THE TIME FOR THE SPEED TO REACH 350 RADIANS/SEC.

(b) THE FINAL SPEED IF THE TORQUE WAS MAINTAINED FOR 10 SECONDS

(c) THE TORQUE INCREASE NECESSARY TO OBTAIN AN INCREASE OF 50 RADIANS/SECOND IN 2.5 SECONDS.

② EXPLAIN (a) MAIN POLE (b) INTERPOLE

③ CALCULATE THE COMMUTATOR BAR PITCH FOR THE FOLLOWING FOUR POLE SIMPLEX WAVE WOUND ARMATURE

(a) 81 BARS (b) 131 BARS (c) 171 BARS.

④ A 240 SEGMENT COMMUTATOR ROTATES AT 1500 RPM. IF A BRUSH SPANS 3 SEGMENTS, CALCULATE COMMUTATION TIME.

⑤ A FOUR POL
CONDUCTORS.
CURRENT I

⑥ AN ARMATURE
GENERATOR
HAS A POLE
MAGNETIZING

⑦ A 75 KW
15% CALC
THE VOLTAGE
FULL LOA
TERMINA

⑧ PROVIDE
NOW WI

⑨ THE E
SHUNT

REVISION

...MOMENT OF INERTIA OF $10 N-m^2$
...F 200 RADIANS PER SECOND. IF THE
...TOR WAS INCREASED BY 50 N-m
...FOR THE SPEED TO REACH 300 RADIANS/SEC.
...PEED IF THE TORQUE WAS MAINTAINED
...ONDS
...E INCREASE NECESSARY TO OBTAIN AN
...OF 50 RADIANS/SECOND IN 25 SECONDS.

INTER POLE
BAR PITCH FOR THE FOLLOWING
...ND ARMATURE
...31 BARS (C) 171 BARS.
...OR ROTATES AT 1500RPM. IF
...ENTS, CALCULATE COMMUTATION TIME.

(5) A FOUR POLES LAP WOUND ARMATURE HAS A TOTAL OF 720 ACTIVE CONDUCTORS. IF THE FLUX PER POLE IS 0.4 wb AND THE ARMATURE CURRENT IS 31.4 AMP, CALCULATE THE TORQUE DEVELOPED.

(6) AN ARMATURE 0.5 m DIAMETER OF A SIX POLE LAP WOUND GENERATOR HAS 378 CONDUCTORS, CARRIES 800 AMP AND HAS A POLE ARC OF 0.17m, CALCULATE THE CROSS MAGNETIZING ARMATURE REACTION AMPERE TURNS.

(7) A 75 KW 500V GENERATOR HAS A VOLTAGE REGULATION 15% CALCULATE (a) OPEN CIRCUIT VOLTAGE (b) ASSUMING THE VOLTAGE VARIES UNIFORMLY BETWEEN NO LOAD AND FULL LOAD CURRENT, CALCULATE KW OUTPUT FOR TERMINAL VOLTAGE OF 510V

(8) PROVIDE YOUR OWN VIEW WHY AC GENERATORS ARE NOW WIDELY USED

(9) THE EXTERNAL CHARACTERISTICS OF A SELF EXCITED SHUNT GENERATOR IS AS FOLLOWS:-

TERMINAL VOLT...
AMPERE
DETERMINE (a...
(b...
(10) SKETC...

(1) $I = 1$...
$T = 5$...
(a) $\omega_2 = 3$...
$\omega_2 =$...
$T =$...
$50 = 1$...

HAS A TOTAL OF 720 ACTIVE
0.4 wb AND THE ARMATURE
THE TORQUE DEVELOPED.

A SIX POLE LAP WOUND
ARRIES 800 Amp AND
LATE THE CROSS
MPERE TURNS.

A VOLTAGE REGULATION
VOLTAGE (b) ASSUMING
ETWEEN NO LOAD AND
KW OUTPUT FOR

AC GENERATORS ARE

S OF A SELF EXCITED

WS:-

TERMINAL VOLTAGE	144	142	136	133	127	120	108	100
AMPERE	0	10	20	30	40	50	60	65

DETERMINE (a) THE LOAD VOLTAGE AND CURRENT FOR A LOAD RESISTANCE OF 2Ω

(b) TOTAL LOAD RESISTANCE AND CURRENT FOR A TERMINAL VOLTAGE OF 120V.

10 SKETCH (a) LONG SHUNT COMPOUND GENERATOR
(b) SHORT SHUNT COMPOUND GENERATOR
(c) SHUNT GENERATOR
(d) SERIES GENERATOR
(e) SEPARATELY EXCITED GENERATOR

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1 $I = 10\ N\text{-}m^2$, $\omega_1 = 200$ rad/s

$T = 500\ N\text{-}m$

(a) $\omega_2 = 300$ rad/s $\quad t = ?$

$\omega_2 = \omega_1 + \alpha t$

$T = I\alpha$

$50 = 10\alpha \rightarrow \alpha = \frac{50}{10} = 5\ \text{rad/s}^2$

$\omega_2 = \omega_1 + \alpha t$

$300 = 200 + 5 \times t$

$\frac{300-200}{5} = t$

$t = 20\ \text{sec}$

(b) $\omega_2 = \omega_1 + \alpha t$
$= 200 + 5 \times 10 = 250$ rad/sec

(c) $\Delta W = 50$ rad/sec

$\Delta t = 25$ sec

$\alpha = \frac{\Delta W}{\Delta t} = \frac{50}{25} = 2\ \text{rad/s}^2$

$T = I\alpha = 10 \times 2 = 20$ N-m

---

2 (a) MAIN POLE IS THE MAJOR POLE THAT PROVIDES MAIN FLUX DENSITY

(b) THE INTERPOLES ARE PLACED BETWEEN THE MAIN POLES TO IMPROVE THE COMMUTATION.

(b) $w_2 = w_1 + \alpha t$

$= 200 + 5 \times 10 = 250$ rad/sec

(c) $\Delta w = 50$ rad/sec

$\Delta t = 25$ sec

$\alpha = \dfrac{\Delta w}{\Delta t} = \dfrac{50}{25} = 2$ rad/s^2

$T = I\alpha = 10 \times 2 = 20$ N-m

2 (a) MAIN POLE IS THE MAJOR POLE THAT PROVIDES MAIN FLUX DENSITY

(b) THE INTERPOLES ARE PLACED BETWEEN THE MAIN POLES TO IMPROVE THE COMMUTATION.

(3) $y = \dfrac{c \pm m}{P/2}$

(a) $y = \dfrac{81 \pm 1}{4/2}$

$= \dfrac{81+1}{2}$ (OR) $\dfrac{81-1}{2}$

$= 41$ (OR) 40

(b) $y = \dfrac{131 \pm 1}{4/2}$

$= \dfrac{131 \pm 1}{2}$

$= \dfrac{131+1}{2}$ (OR) $\dfrac{131-1}{2}$

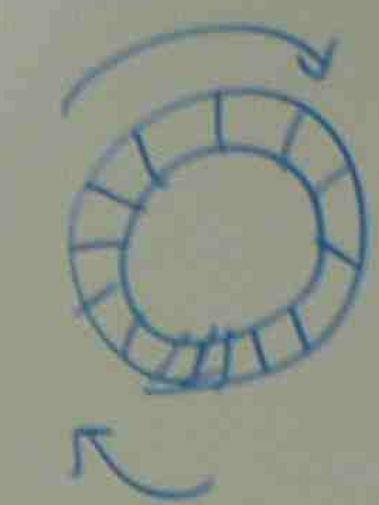
$= 66$ (OR) 65

(c) $y = \dfrac{171 \pm 1}{2}$

$= \dfrac{172}{2}$ (OR) $\dfrac{170}{2}$

$= 86$ (OR) 85

(4)



1 REVOLUTION $\Rightarrow$ 240 SEGMENTS.

1500 RPM $\rightarrow$ 1500 REVOLUTION $\rightarrow$ 1 MINUTE (OR) 60 sec

240×1500 SEGMENT $\rightarrow$ 60 sec

3 SEGMENT — ? COMMUTATION TIME

$\dfrac{60 \times 3}{240 \times 1500} = 5 \times 10^{-4}$ sec

COMMUTATION TIME

(5) P = 4, Z=

$I_a = 3$

T = ?

$T = \dfrac{\phi Z}{2\pi}$

a = No. of AR PARALL

a =

=

$T = \dfrac{0.}{2}$

=

$\Rightarrow$ 240 SEGMENTS.

1500 REVOLUTION $\rightarrow$ 1 MINUTE (OR) 60 SEC

SEGMENT $\rightarrow$ 60 SEC

SEGMENT — ? COMMUTATION TIME

$\frac{3}{1500} = 5\times10^{-4}$ sec COMMUTATION TIME

⑤ $p=4$, $Z=720$, $\phi=0.4$ wb

$I_a = 31.4$ Amp.

$T = ?$

$T = \frac{\phi Z I_a}{2\pi a}$ N-m

a = No. of ARMATURE PARALLEL PATHS $= m \times P$ (LAP)

$m = 1$ SIMPLEX, 2 DUPLEX

$a = m \times 2$ (WAVE)

$a = m \times p$ (LAP)
$= 1 \times 4 = 4$

$T = \frac{0.4 \times 720 \times 31.4}{2 \times 3.1416 \times 4}$

$= 144$ N-m

⑥ $Z = 378$, $I_a = 800$, $P = 6$

pole arc $= 0.17$ m

$AT_c = ?$ (CROSS MAGNETIZING AMP-TURNS)

$AT_c = \frac{\text{pole arc/pole}}{\frac{\text{CIRCUMFERENCE}}{\text{No. of poles}}} \times \frac{Z I_a}{2 a P}$

LAP

$a = m \times P = 1 \times 6 = 6$

CIRCUMFERENCE $= \pi D$
$= 3.1416 \times 0.5$

$AT_c = \frac{0.17}{\frac{3.1416\times0.5}{6}} \times \frac{378 \times 800}{2 \times 6 \times 6}$

$= 2740$ AT/pole

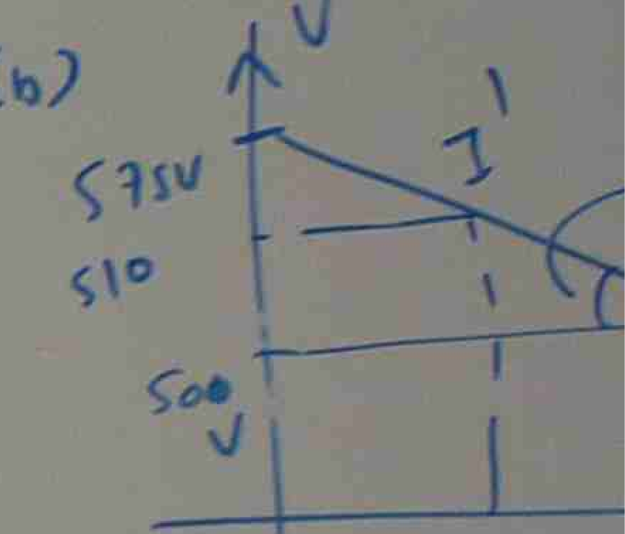
⑦ % REG $= \frac{V_{NL}}{\ldots}$

$15 = \frac{V_{NL} - \ldots}{500}$

$\frac{15 \times 500}{100} = V_{N\ldots}$

(a) $V_{NL} = \frac{15\times 50\ldots}{100}$

(b)



$I_{FL} = \frac{\text{RATED} \ldots}{\text{FULL LOA}\ldots \text{ VOLTA}\ldots}$

$= \frac{75\times\ldots}{50\ldots}$

$= 15\ldots$

ϕ = GRADIEN…

78, $I_a = 800$, $P = 6$

RC = 0.17 m

= ? (CROSS MAGNETIZING AMP-TURNS)

$$\frac{\text{OLE ARC/POLE}}{\frac{\text{IRCUMFERENCE}}{\text{No. of poles}}} \times \frac{Z I_a}{2aP}$$

$\times P = 1 \times 6 = 6$

ERENCE $= \pi D$

$= 3.1416 \times 0.5$

$$\frac{0.17}{\frac{3.1416 \times 0.5}{6}} \times \frac{378 \times 800}{2 \times 6 \times 6}$$

2740 AT/pole

7

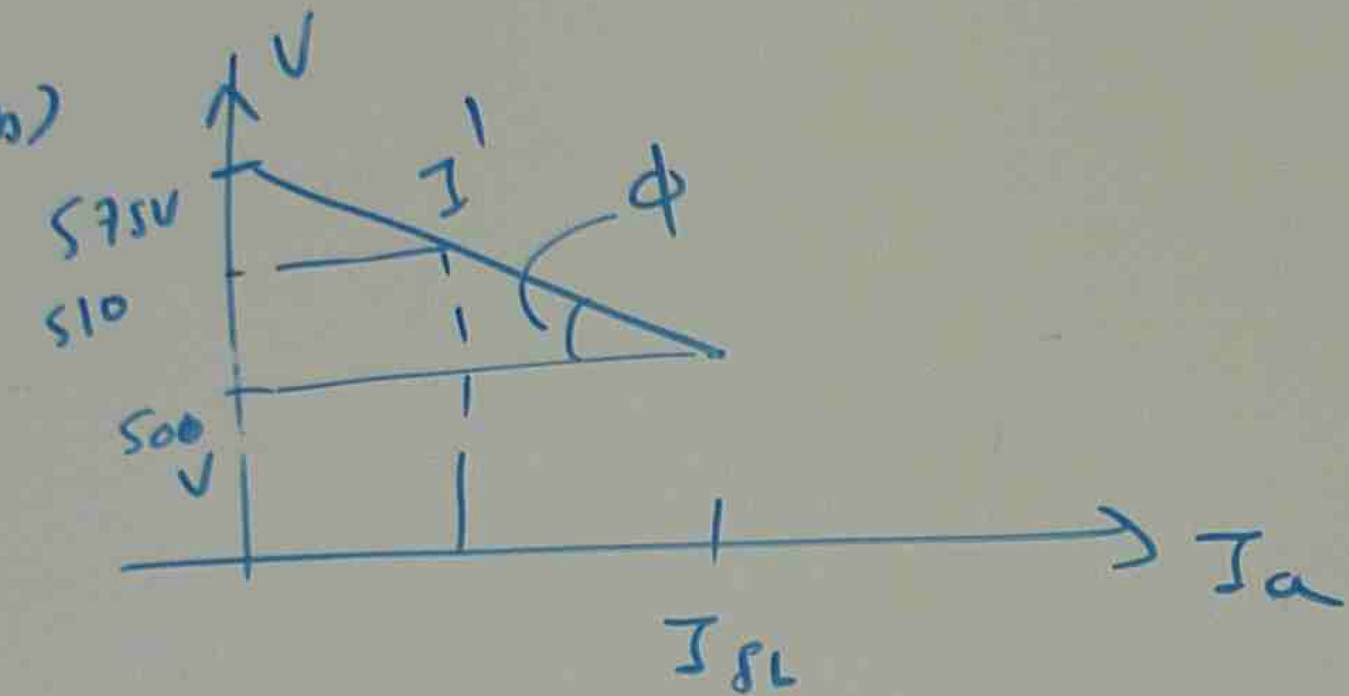
$$\%\text{REG} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$$

$$15 = \frac{V_{NL} - 500}{500} \times 100$$

$$\frac{15 \times 500}{100} = V_{NL} - 500$$

(a) $V_{NL} = \frac{15 \times 500}{100} + 500 = 575\,V$

(b)



$$I_{FL} = \frac{\text{RATED POWER}}{\text{FULL LOAD TERMINAL VOLTAGE}}$$

$$= \frac{75 \times 1000}{500}$$

$= 150$ Amp.

$$\phi = \text{GRADIENT} = \frac{V_1 - V_2}{I_1 - I_2} = \frac{575 - 500}{0 - 150}$$

$$= \frac{75}{-150} = -0.5$$

$$\text{GRADIENT} = \frac{V_1 - V'}{I_1 - I'}$$

$$-0.5 = \frac{575 - 510}{0 - I'}$$

$$-0.5 \times (-I') = 65$$

$$I' = \frac{65}{0.5} = 130 \text{ Amp}$$

8 AC GENERATORS ARE NOW WIDELY USED BECAUSE

(a) AC VOLTAGE CAN BE EASILY CHANGED THE LEVEL

(b) IT IS EASIER TO MAINTAIN AC GENERATORS

(c) HIGHER POWER & VOLTAGE CAN BE PRODUCED BY AC GENERATOR THAN DC GENERATOR.

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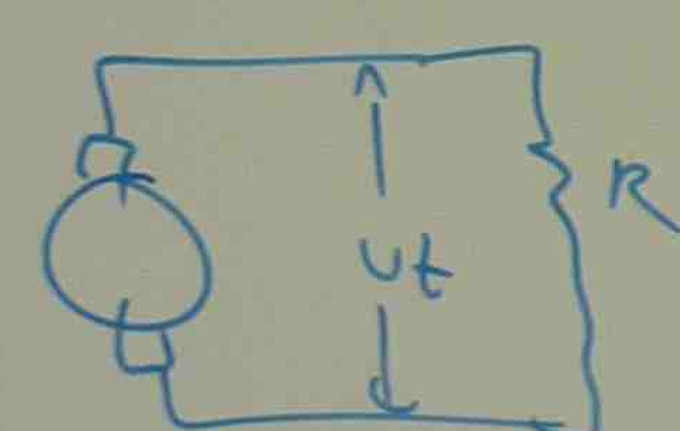
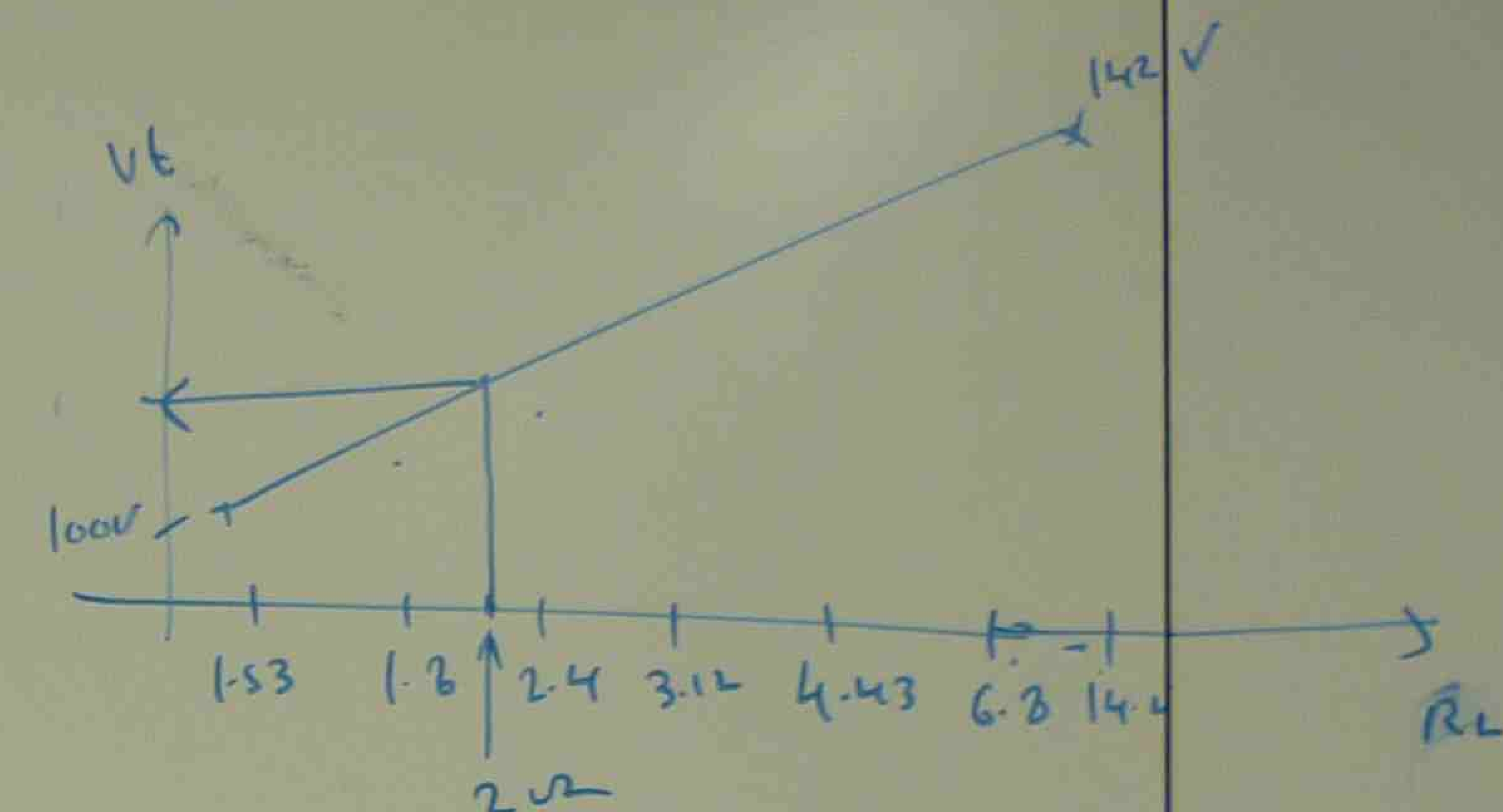
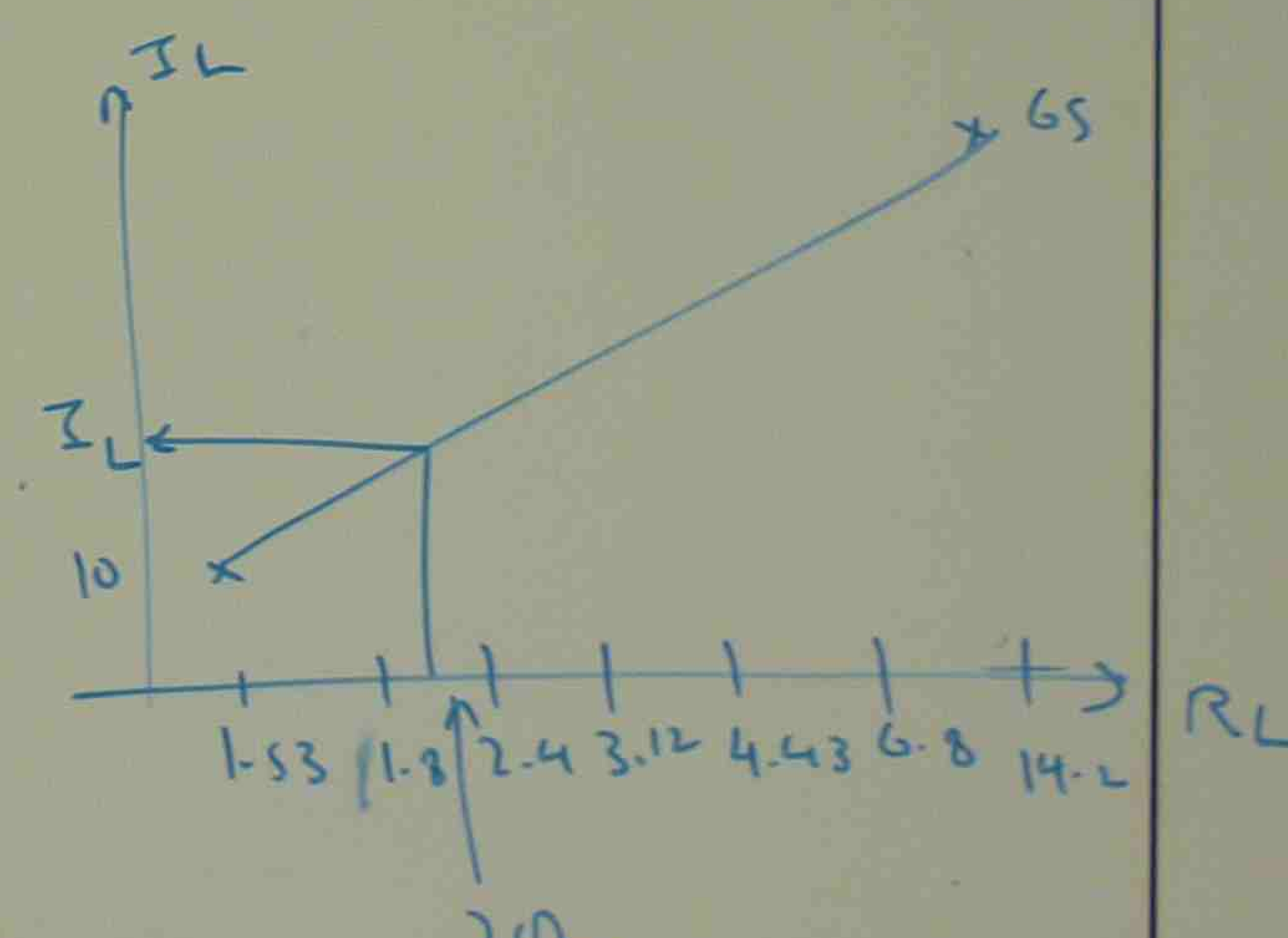
(9) $V_t = I_L \times R_L$



$$R_L = \frac{V_t}{I_L}$$

Vt	142	136	133	127	120	108	100
I_L	10	20	30	40	50	60	65
R_L	14.2 Ω	6.8	4.43	3.12	2.4	1.8	1.53 Ω

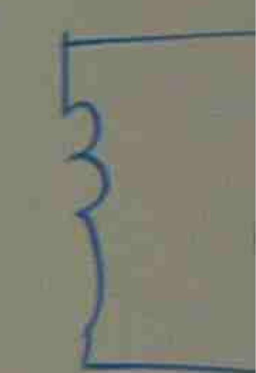




(10)

(a)

(b)

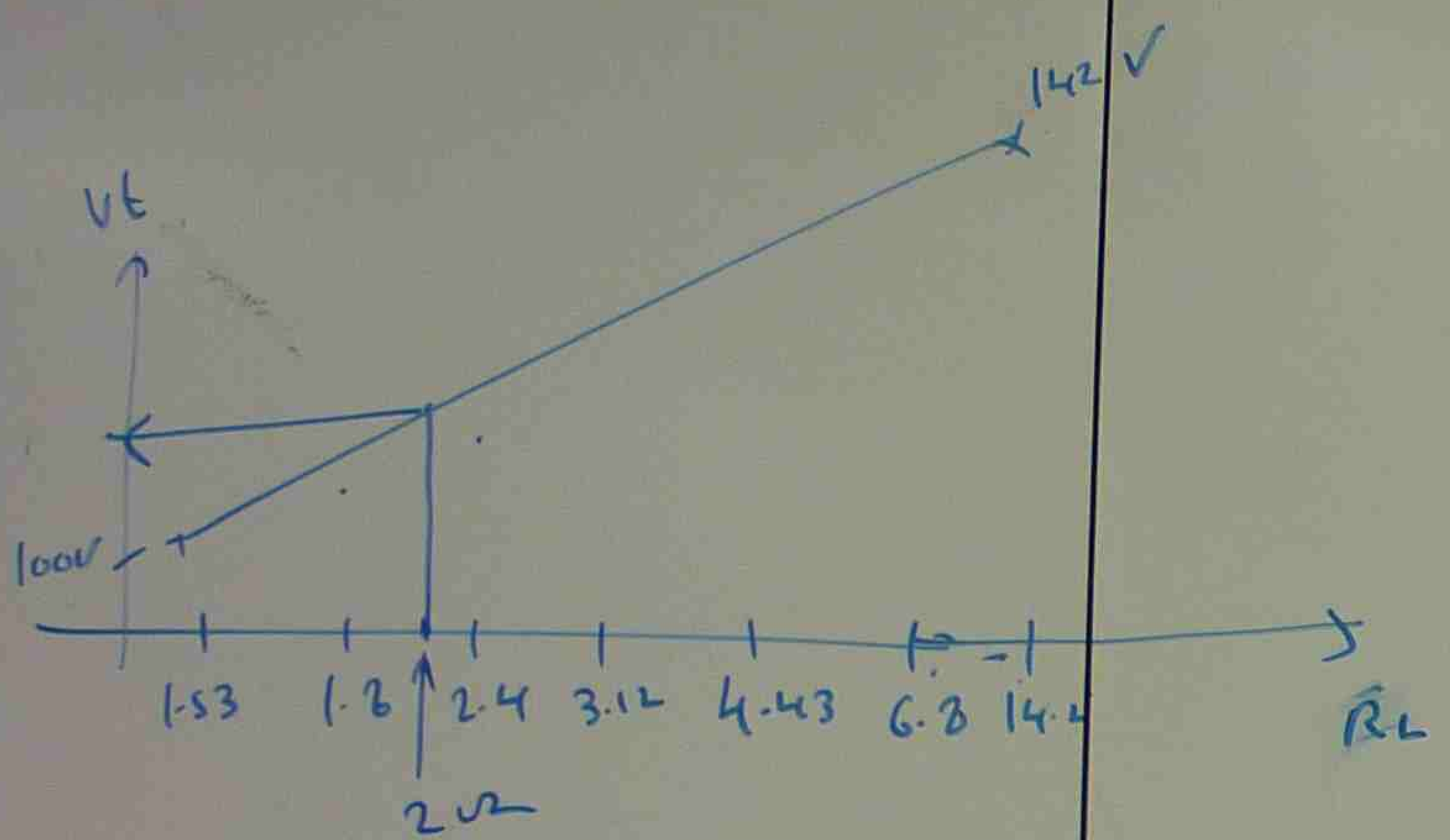


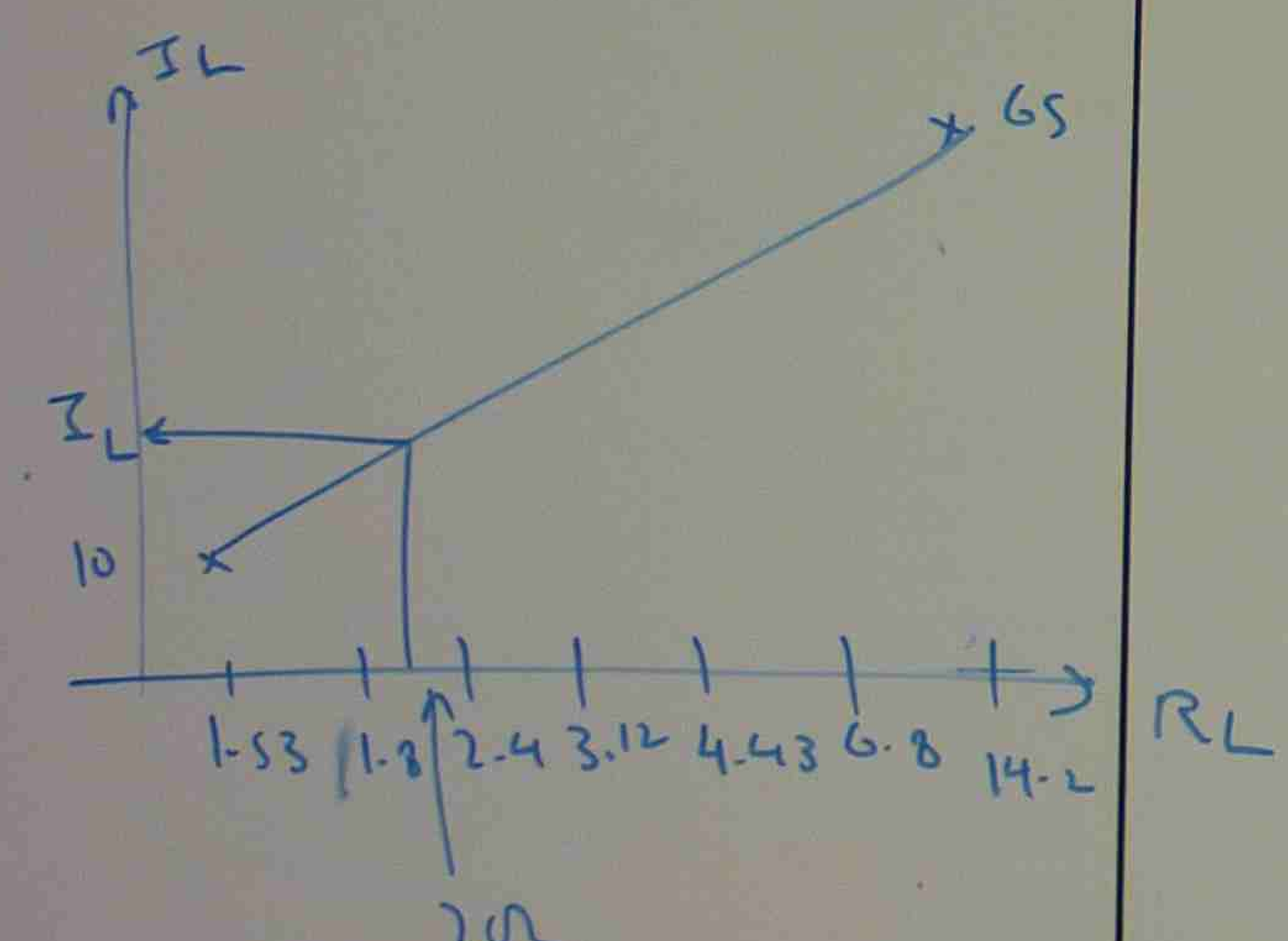
(c)

Rsh

(d)

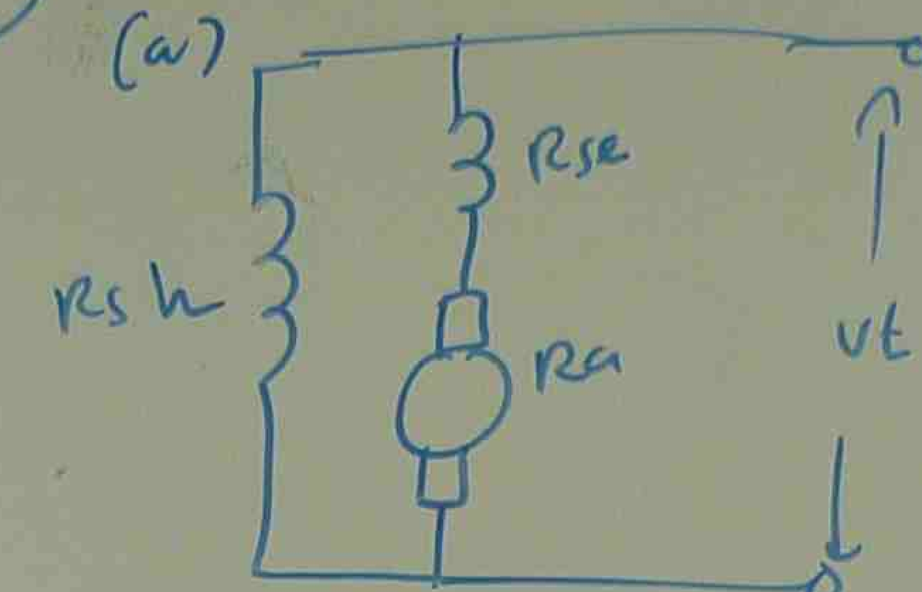
(e)





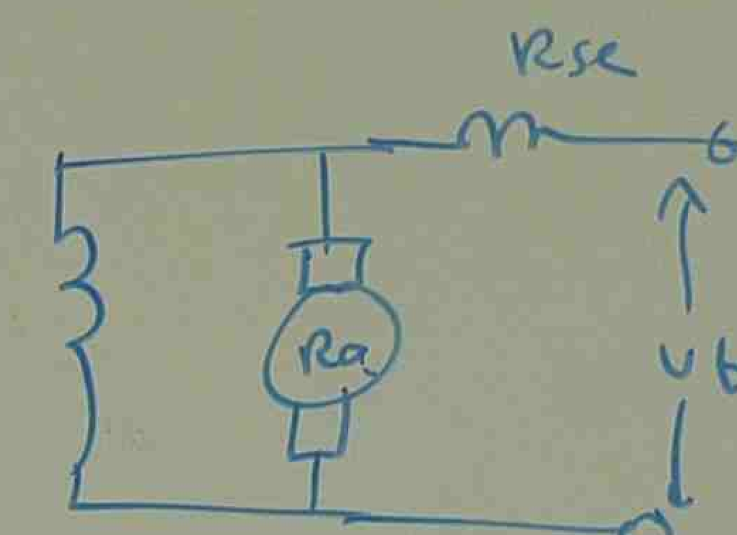
(10)

(a)



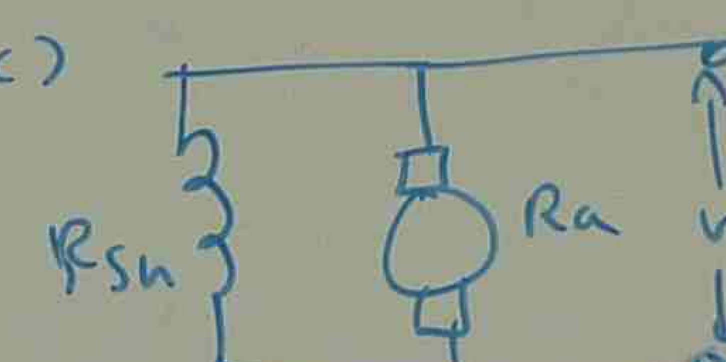
LONG SHUNT COMPOUND

(b)



SHORT SHUNT COMPOUND

(c)

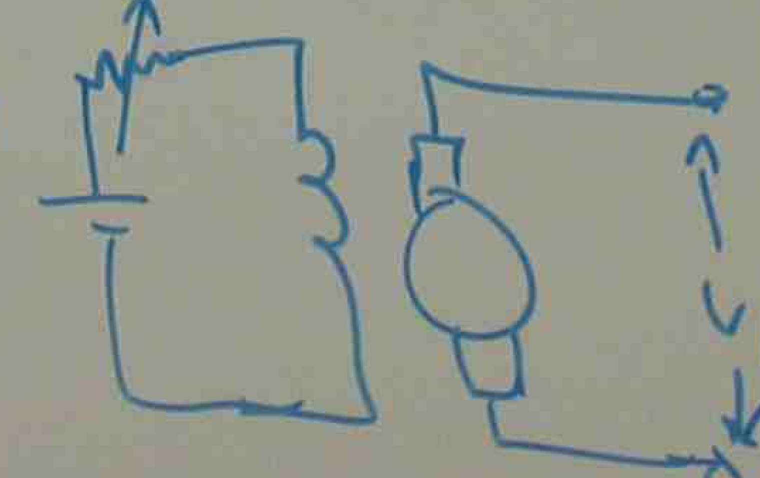


SHUNT

(d)

SERIES

(e)



SEPARATELY EXCITED

(5) $p = 4$, $Z =$

$I_a = 31$

$T = ?$

$T = \frac{\phi Z}{2\pi}$

a = No. of ARM
PARALLE

$a = n$

$= 1$

$T = \frac{0.4}{2 \times}$

$= 1$

$I_a = 800, \; P = 6$

$\cdot 17$ m

(CROSS MAGNETIZING AMP- TURNS)

$\frac{\text{/pole}}{\text{rence / poles}} \times \frac{Z \, I_a}{2aP}$

$1 \times 6 = 6$

$= \pi D$

$= 3.1416 \times 0.5$

$\frac{}{.5} \times \frac{378 \times 800}{2 \times 6 \times 6}$

AT / pole

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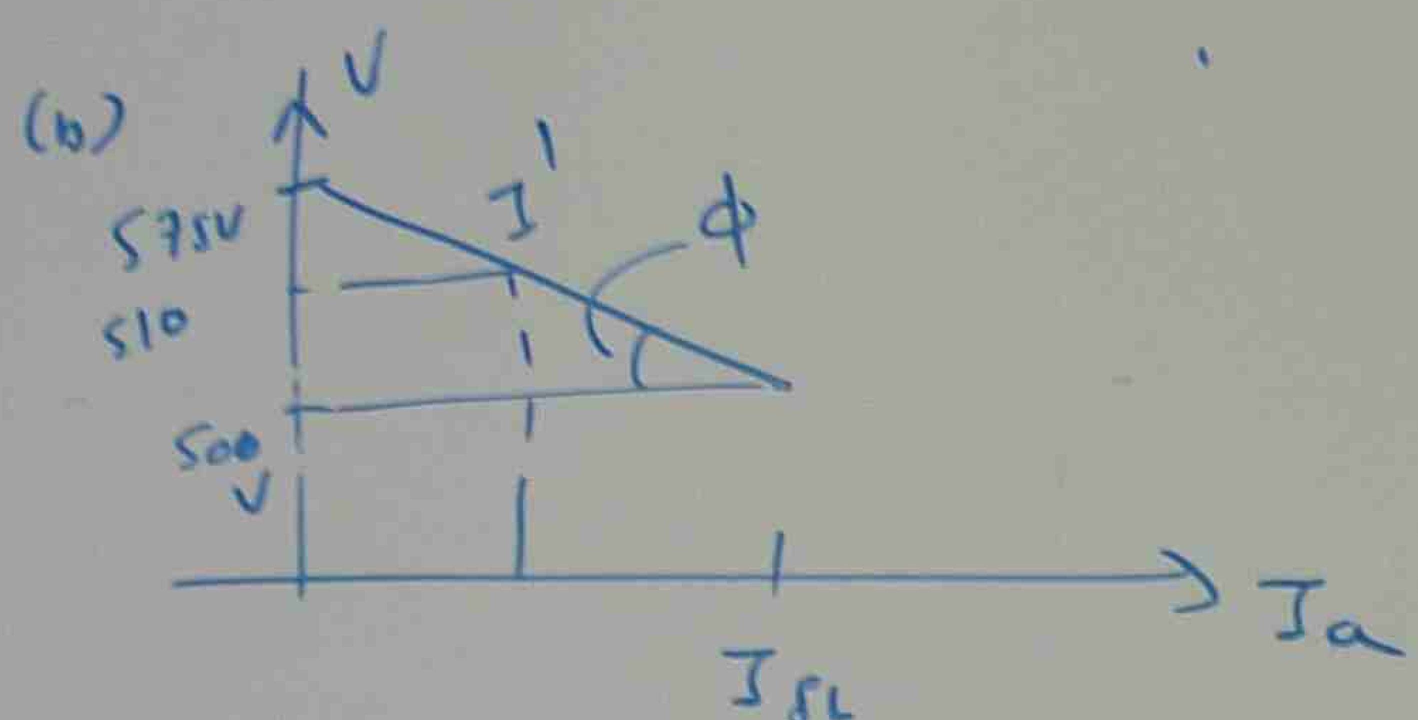

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$-0.5 \times (-I') = 65$

$I' = \frac{65}{0.5} = 130$ Amp

$kW = \frac{510 \times 130}{1000} = 66.3\,kW$

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