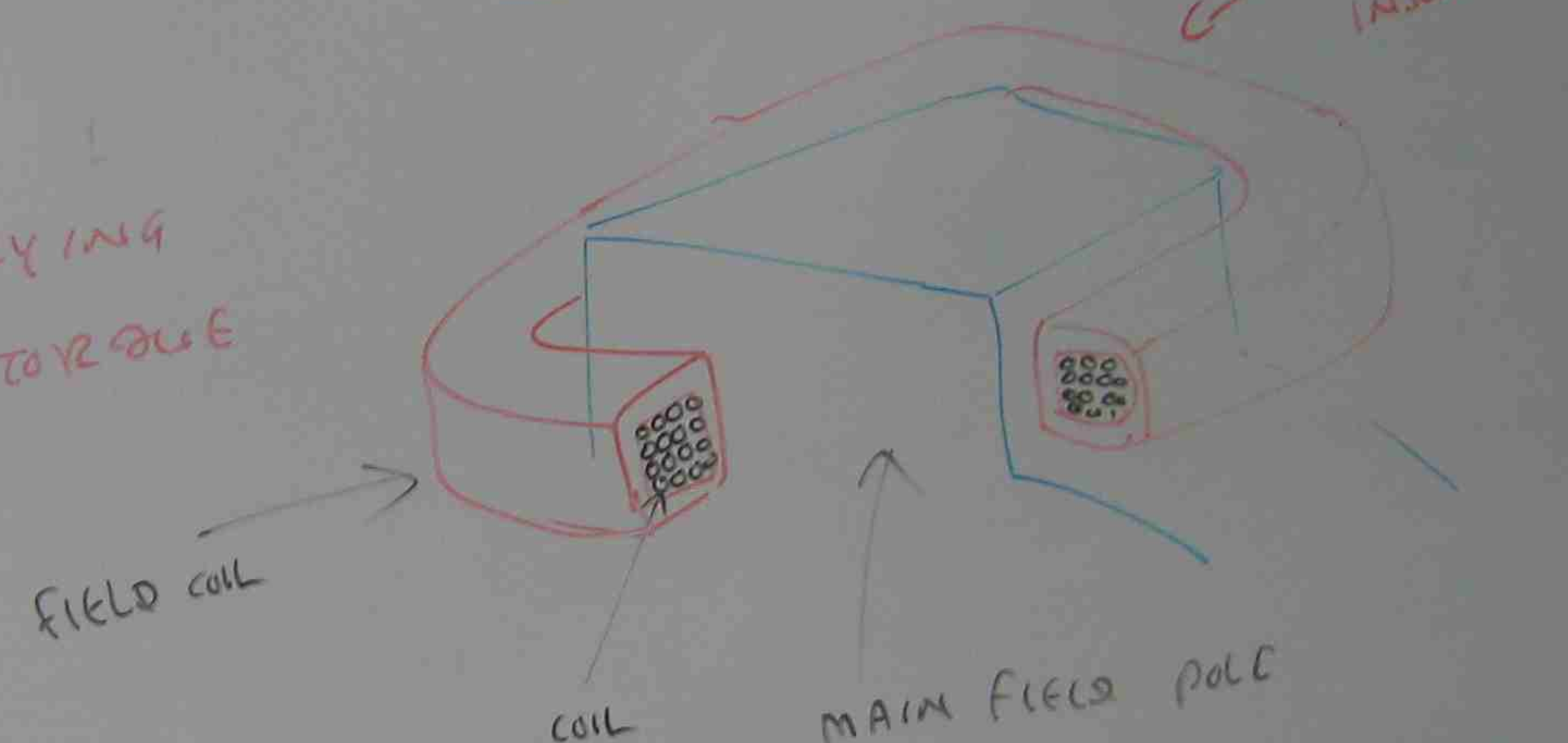
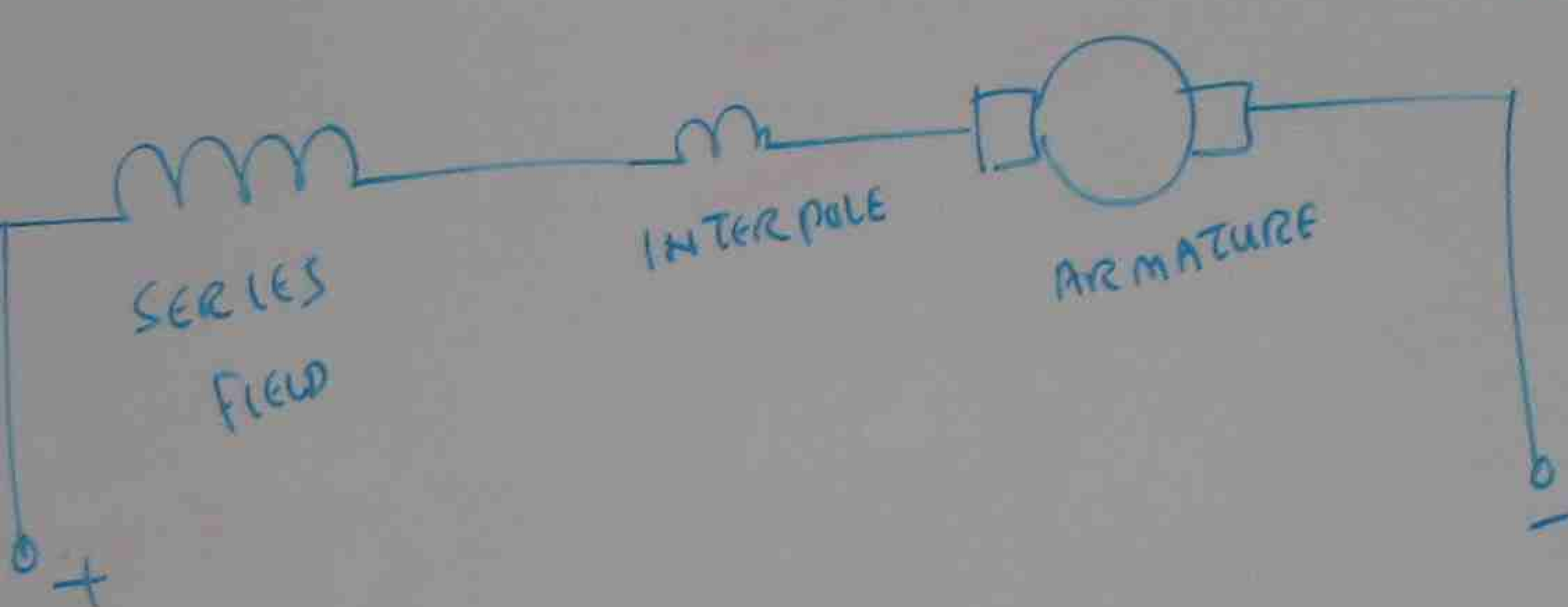
YOKE

MAIN FIELD COIL

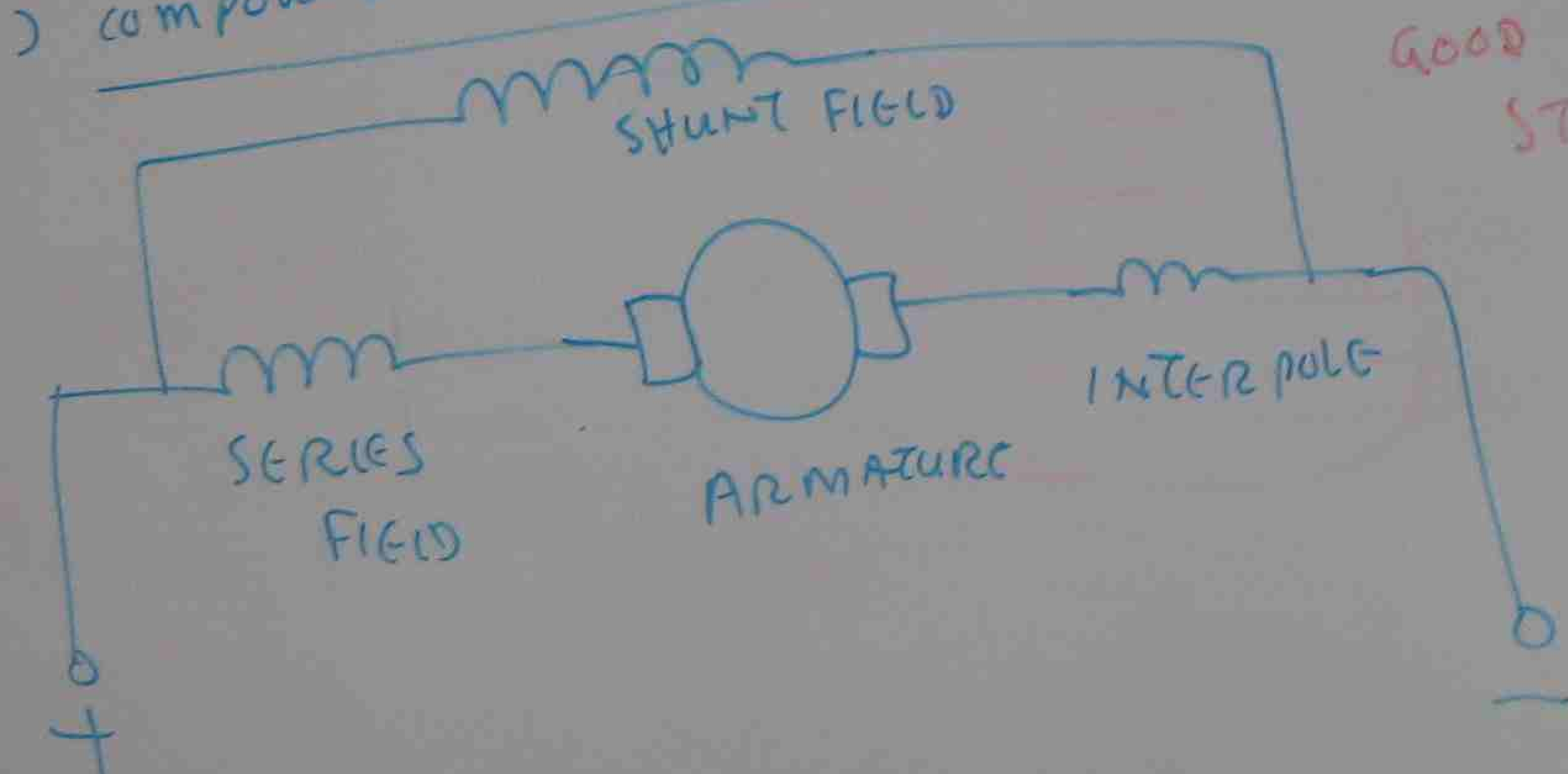


(S)ERIES CONNECTION



VARYING TORQUE

(…) COMPOUND CONNECTION



GOOD FOR STABILITY.

INSULATION — LIQUID INSULATION

INTERWINDING INSULATION.

< HERE

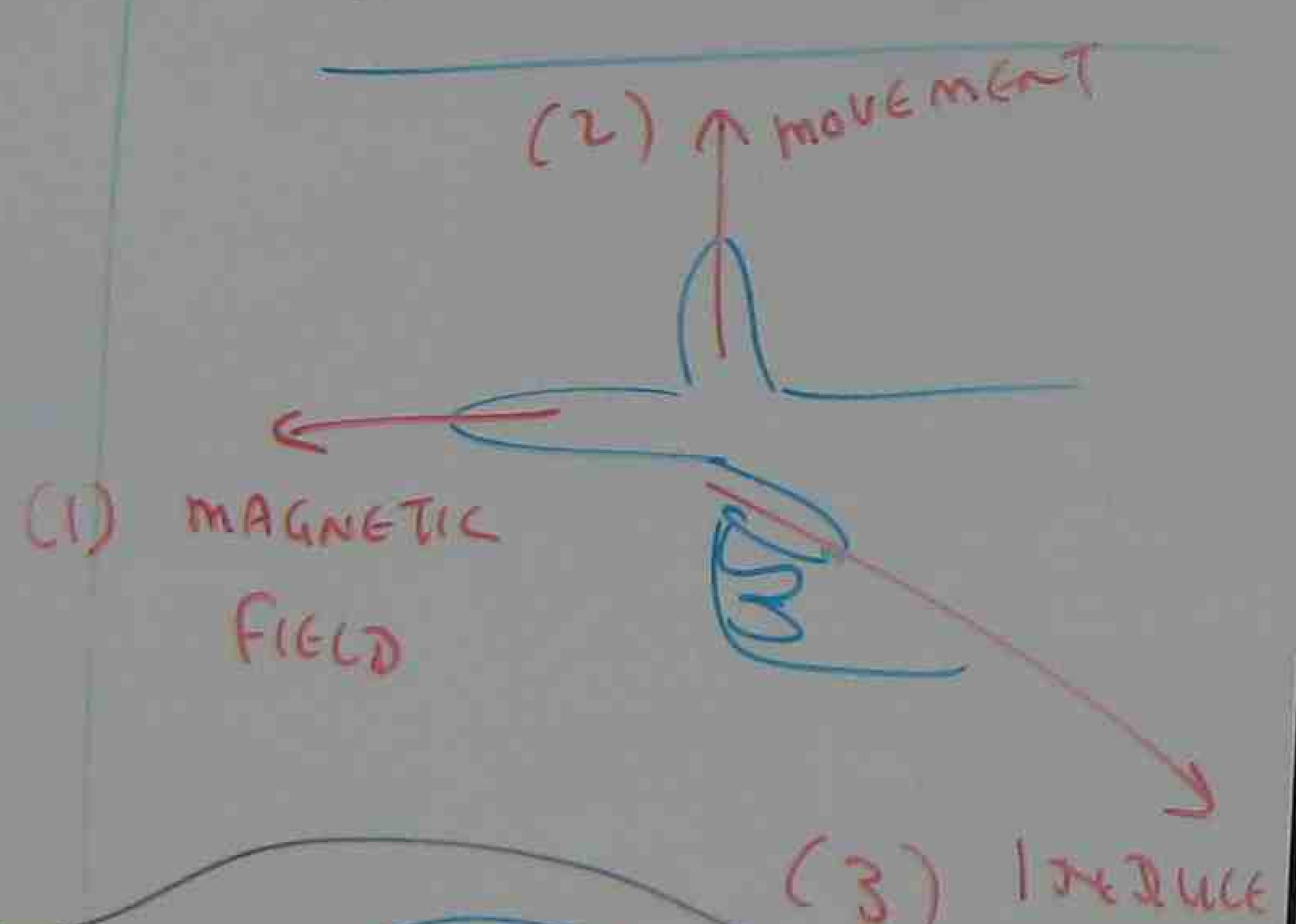
ITE BOARD

DIRECT MACHINE

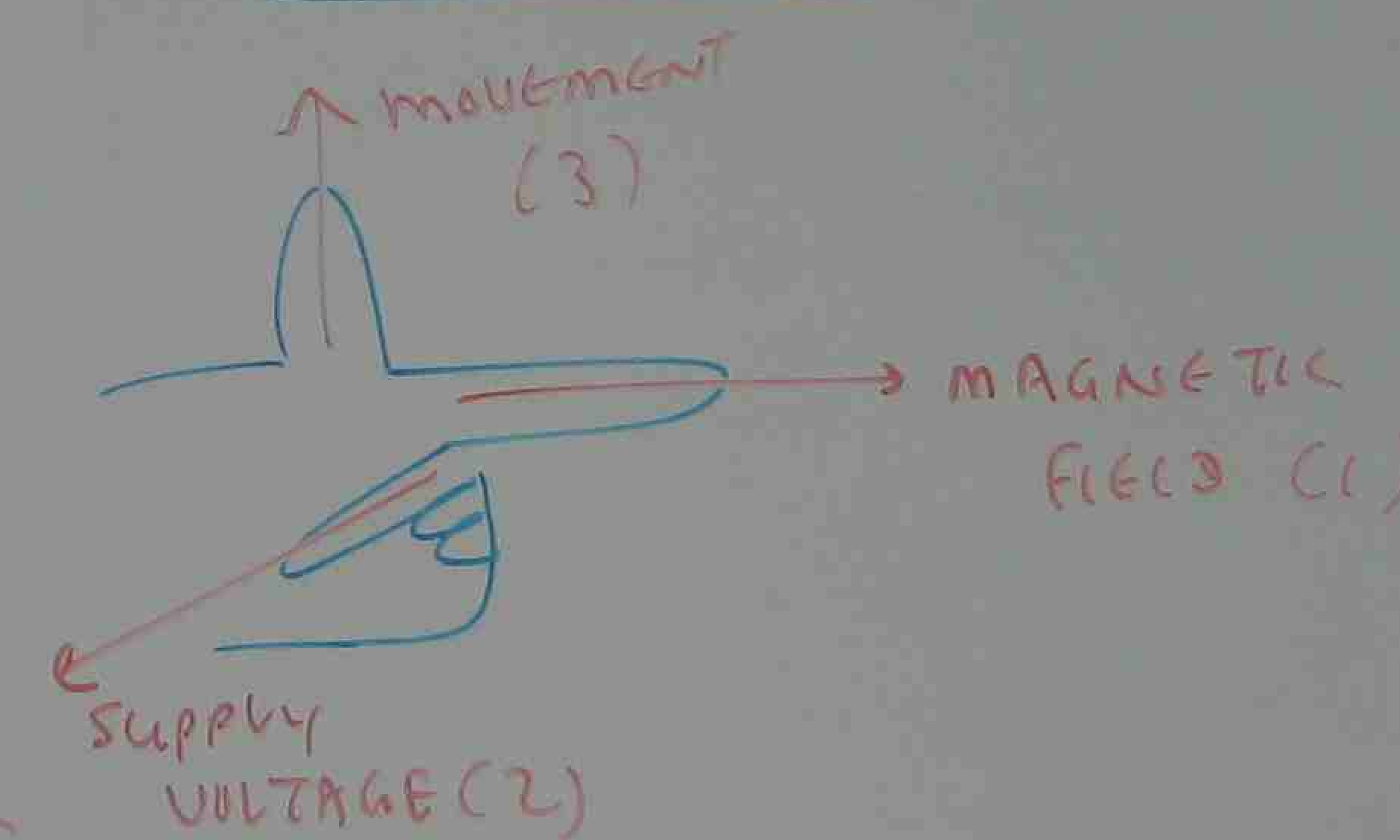
GENERATOR — CONVERT MECHANICAL ENERGY ⟶ ELECTRICAL ENERGY

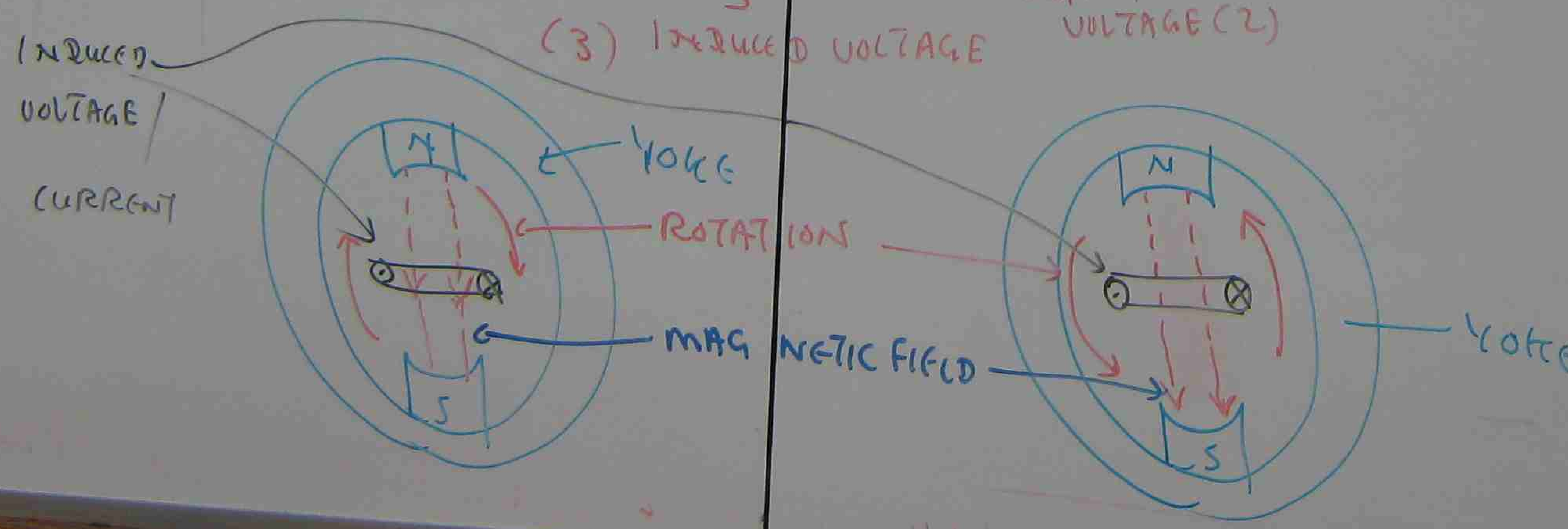
MOTOR — CONVERT ELECTRICAL ENERGY ⟶ MECHANICAL ENERGY

GENERATOR ACTION



MOTOR ACTION





GENERAT

AN EM

MOVES

THAT

THE MA

OF CUT

MOTOR

MOTOR

FORCE

A MA

ON T

ELECTRICAL ENERGY

MECHANICAL ENERGY

TION

MAGNETIC FIELD (I)

YOKE

GENERATOR

AN EMF IS INDUCED IN A CONDUCTOR WHEN THE CONDUCTOR MOVES IN SUCH A DIRECTION RELATIVE TO A MAGNETIC FIELD THAT THE CONDUCTOR CUTS THE MAGNETIC FIELD

THE MAGNITUDE OF THE EMF IS GOVERNED BY THE RATE OF CUTTING

MOTOR

MOTOR ACTION IS BASED UPON THE FACT THAT A MECHANICAL FORCE IS EXERTED ON A CURRENT CARRYING CONDUCTOR IN A MAGNETIC FIELD. THE MAGNITUDE OF THE FORCE DEPENDS ON THE FIELD STRENGTH AND CURRENT.

CONDUCTOR

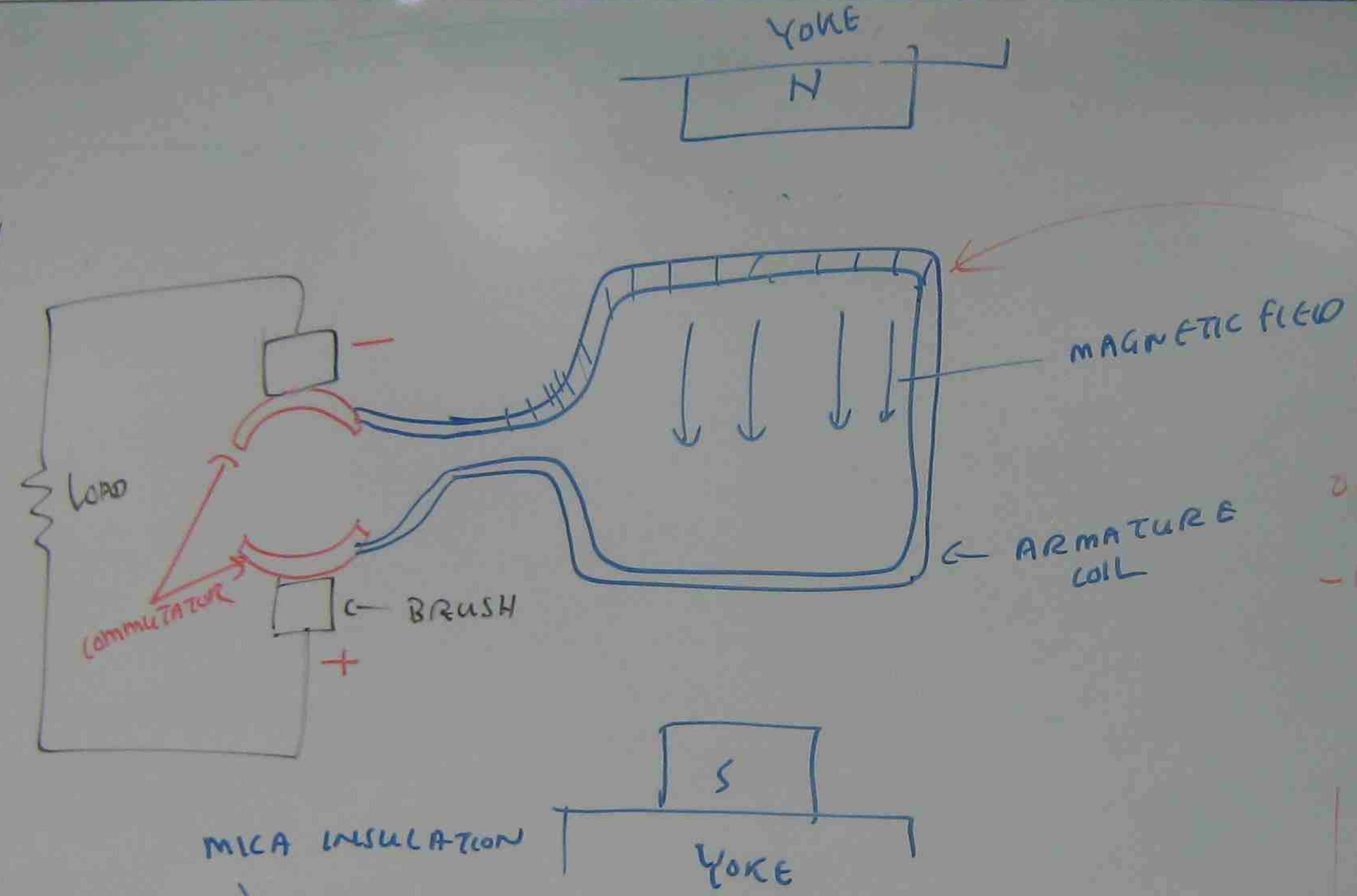
ETIC FIELD

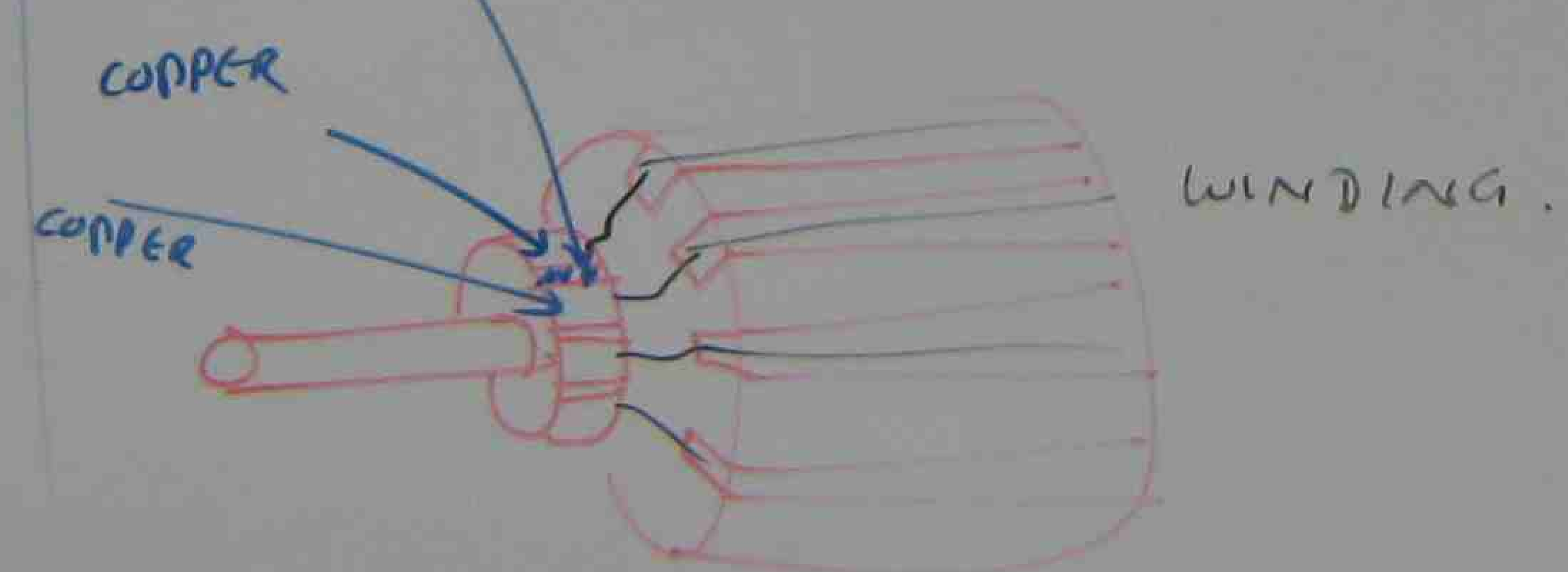
THE RATE

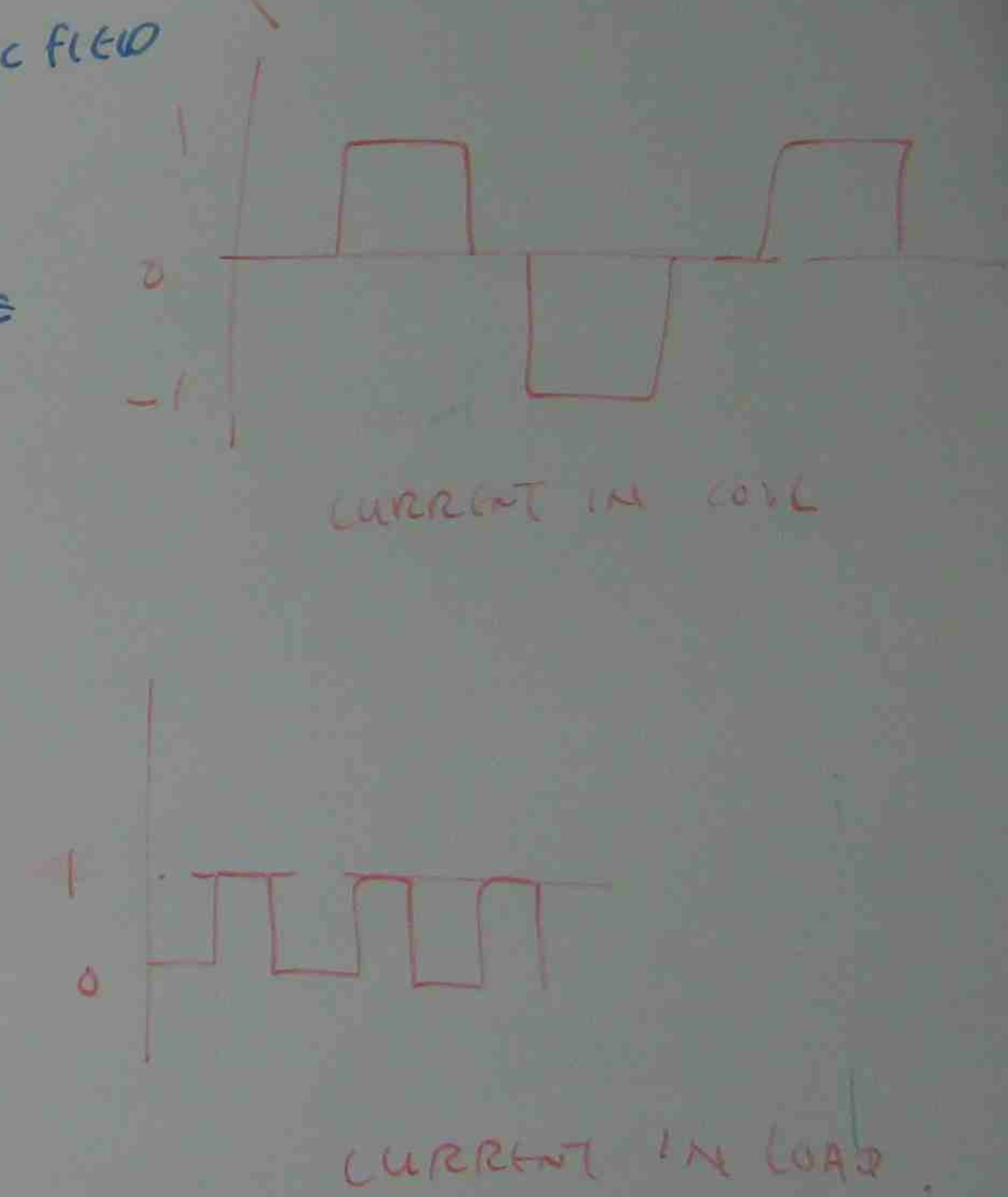
MECHANICAL

CONDUCTOR IN

RCE DEPENDS







GENERATED VOLTAGE EQUATION

$$\boxed{e = B\,L\,V\,\sin\theta}$$

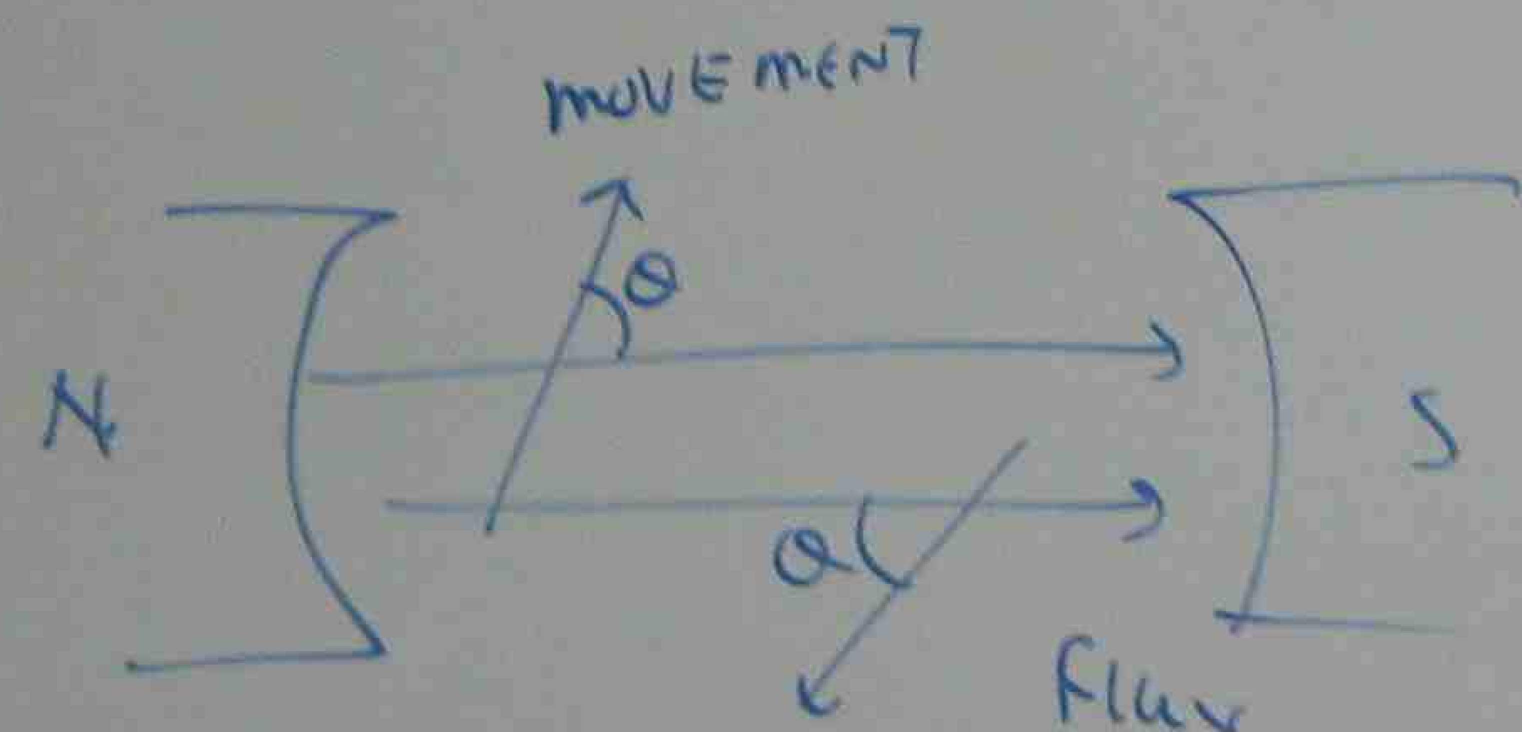
e = GENERATED VOLTAGE (VOLT)

B = FIELD FLUX DENSITY (TESLA)

L = EFFECTIVE LENGTH OF CONDUCTOR (m)

V = VELOCITY OF CONDUCTOR

θ = ANGLE BETWEEN FLUX AND MOVEMENT



ELECTRICAL

PARTS

MAIN pole

INTERPOLE

n)

VEMENT

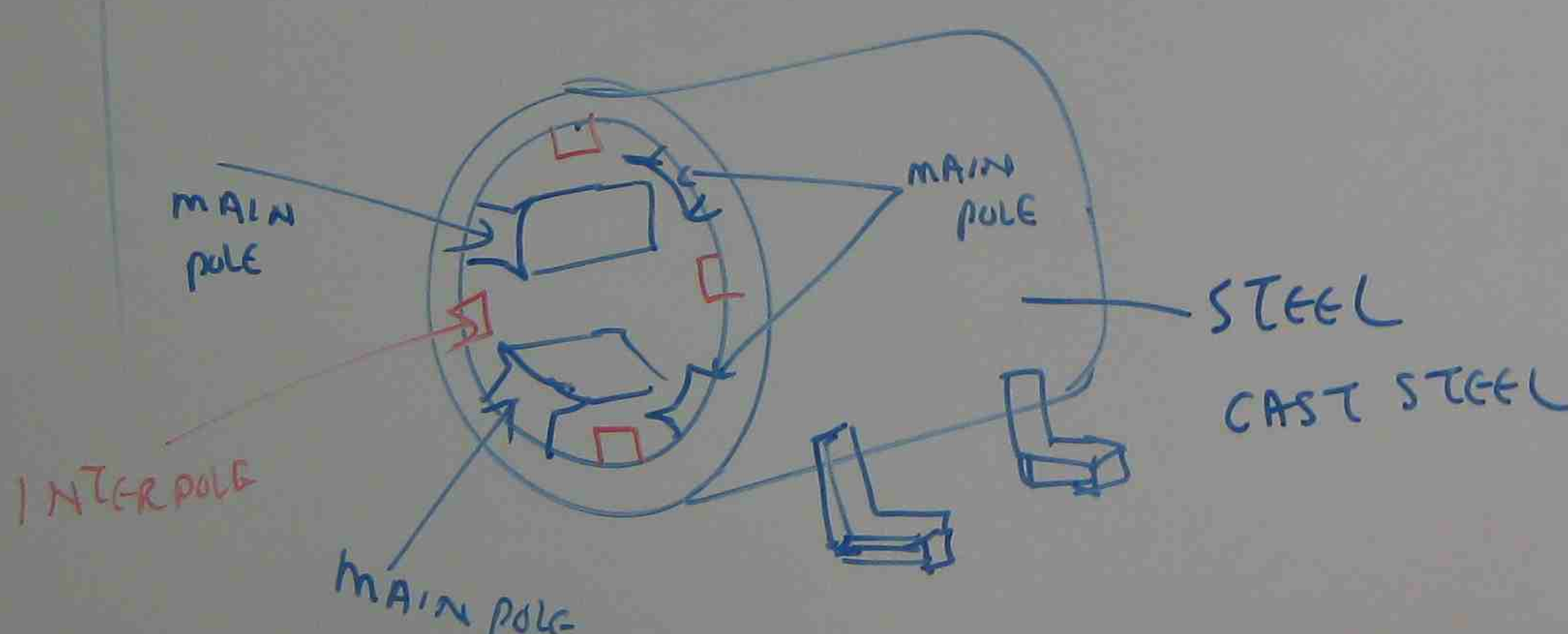
$$\boxed{\text{ELECTRICAL POWER OUTPUT } (P) = BLV \sin\theta \; I}$$

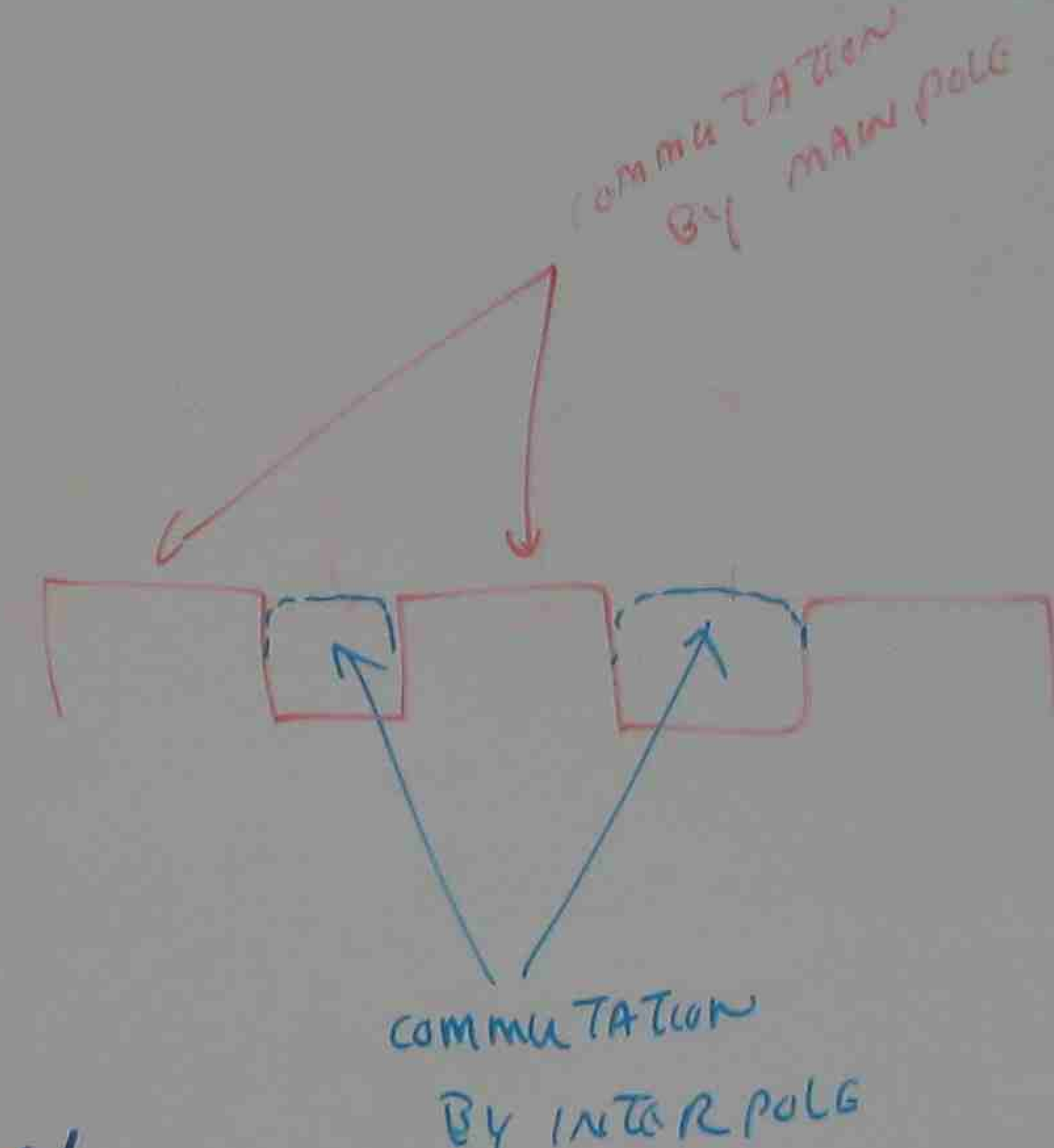
P = ELECTRICAL POWER (WATT)

I = CURRENT (AMPERE)

PARTS OF DC MACHINE

YOKE (FRAME, BODY)





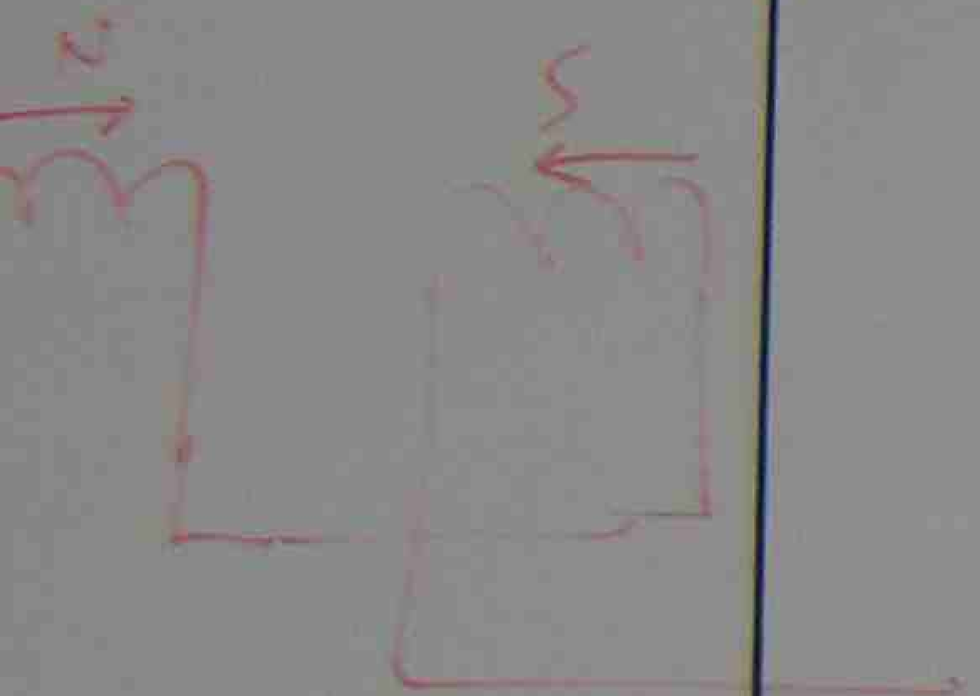
MAIN POLE

ARMATURE

SHAFT

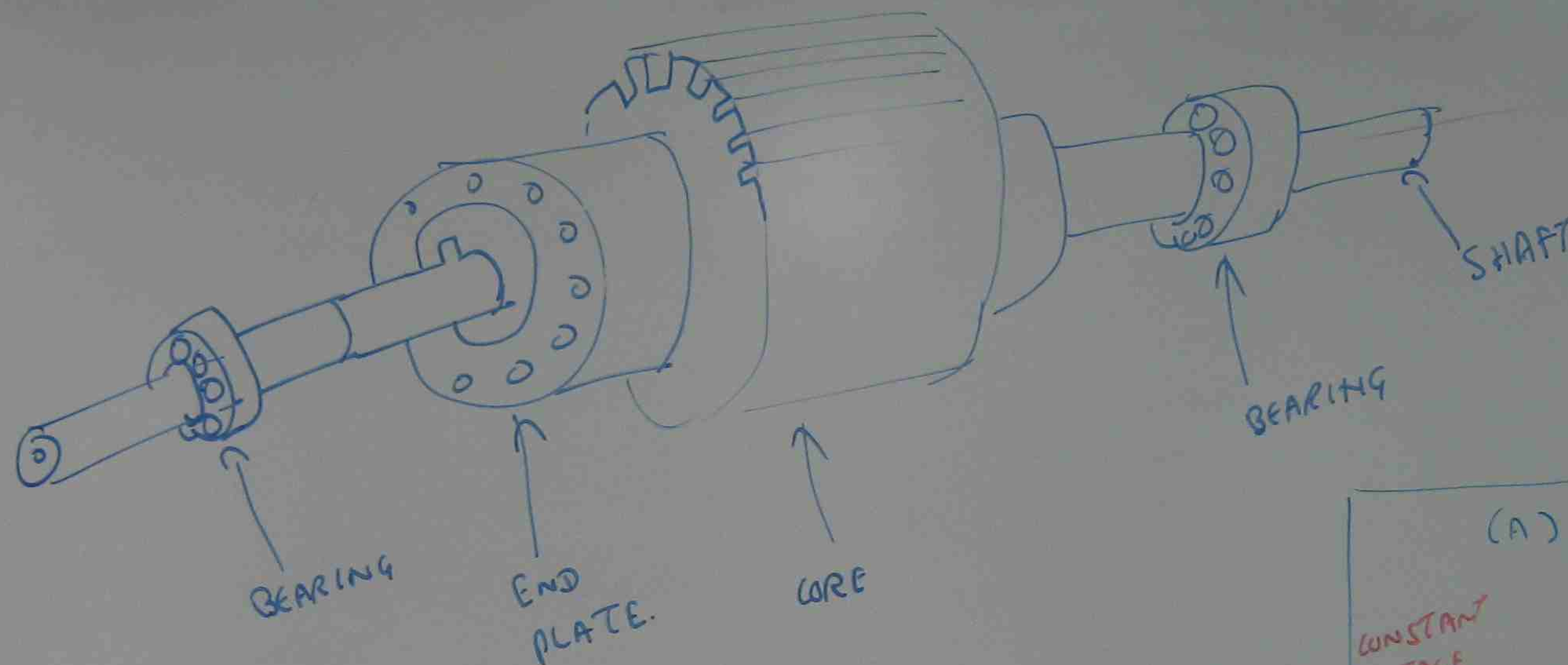
I
COMMUTATION BY MAIN POLE
COMMUTATION BY INTERPOLE
MAIN POLE
COIL
RIVET
LAMINATION
| → 1.5mm TICK STEEL PLATES.
N
S
N
S
N
WINDING COIL
SLOT
ARMATURE
0.6 → 0.8mm LAMINATED STEEL SHEET
AIR VENTILATION DUCTS.
SHAFT
COMMUTATOR
— HARD DRAW
— INSULATION
BRUSH
CARBON BRUSH

1 → 1.5mm
TICK
STEEL PLATES.



.6 → 0.8mm
AMINATED STEEL
SHEET

ENTILATION
UCTS.

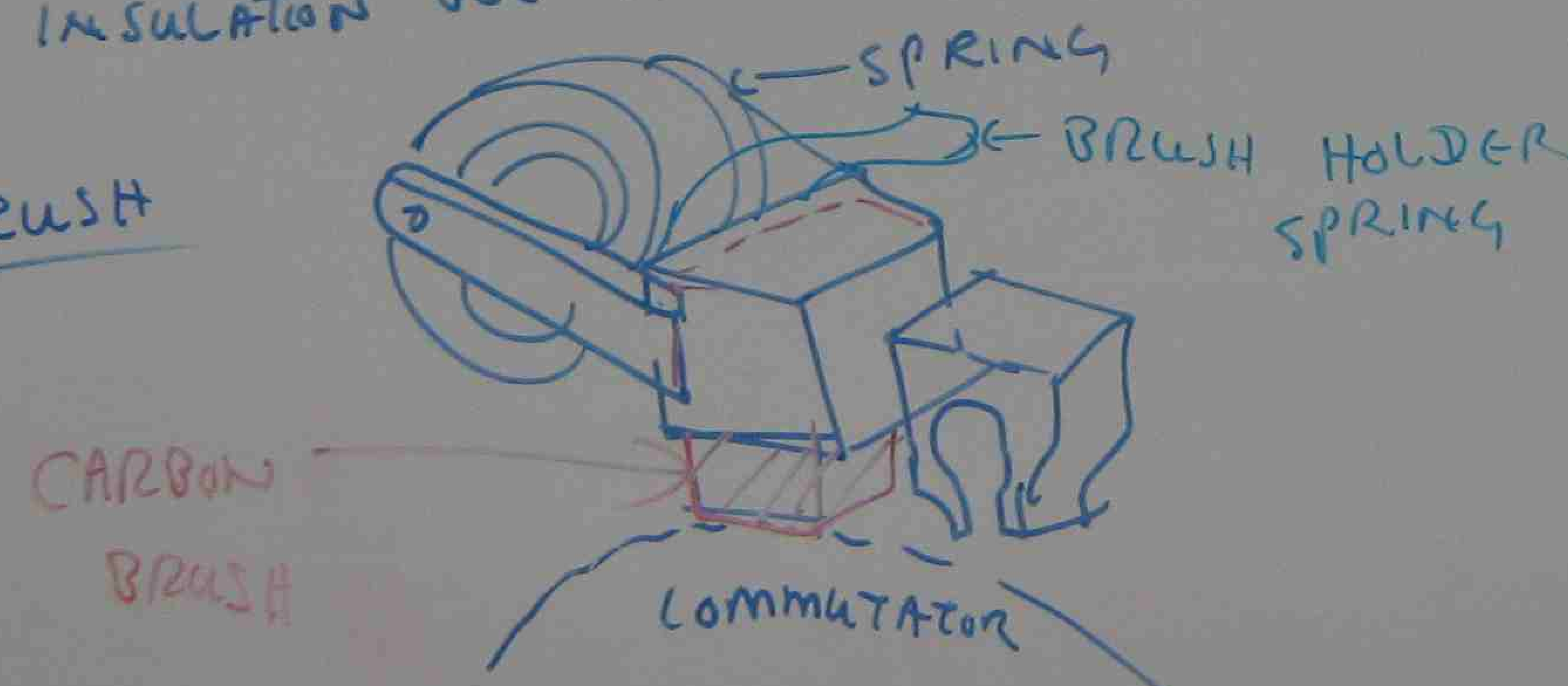


COMMUTATOR

— HARD DRAWN OR SILVERED COPPER

— INSULATION VEE ARE FILLED WITH MICA

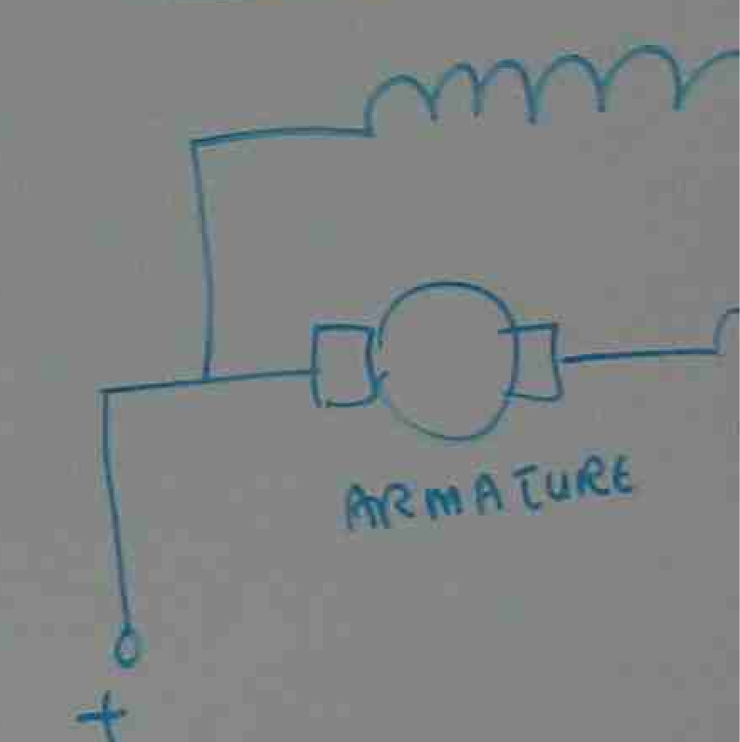
BRUSH



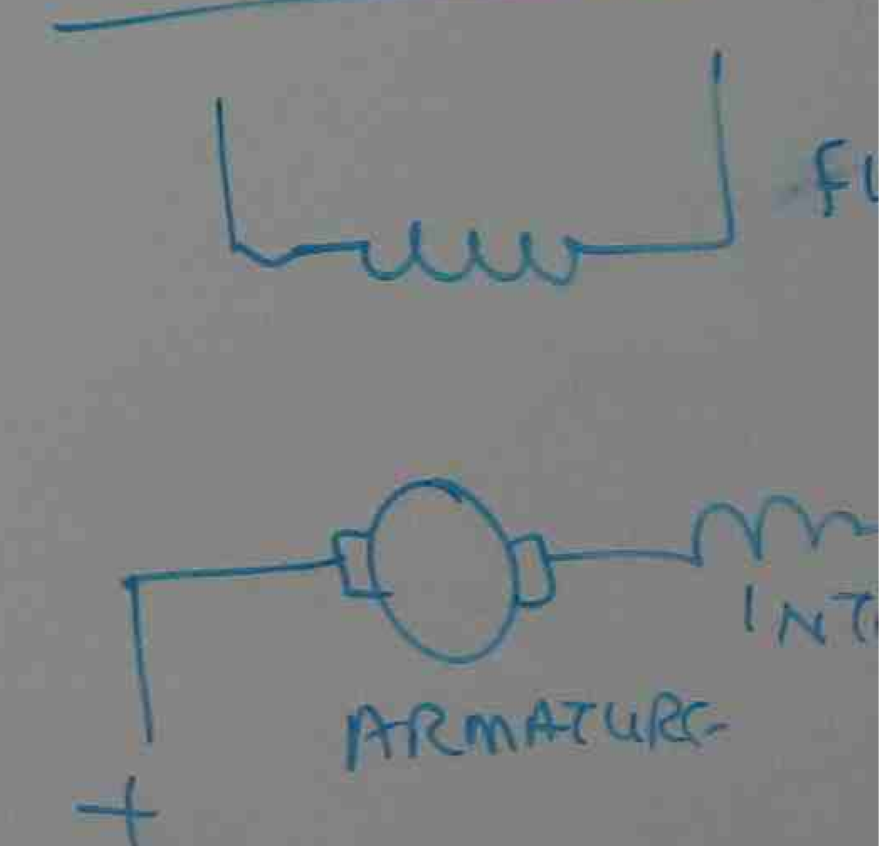
CON N

(A) SHUNT CON

CONSTANT
VOLTAGE



(B) SEPARATELY EXC



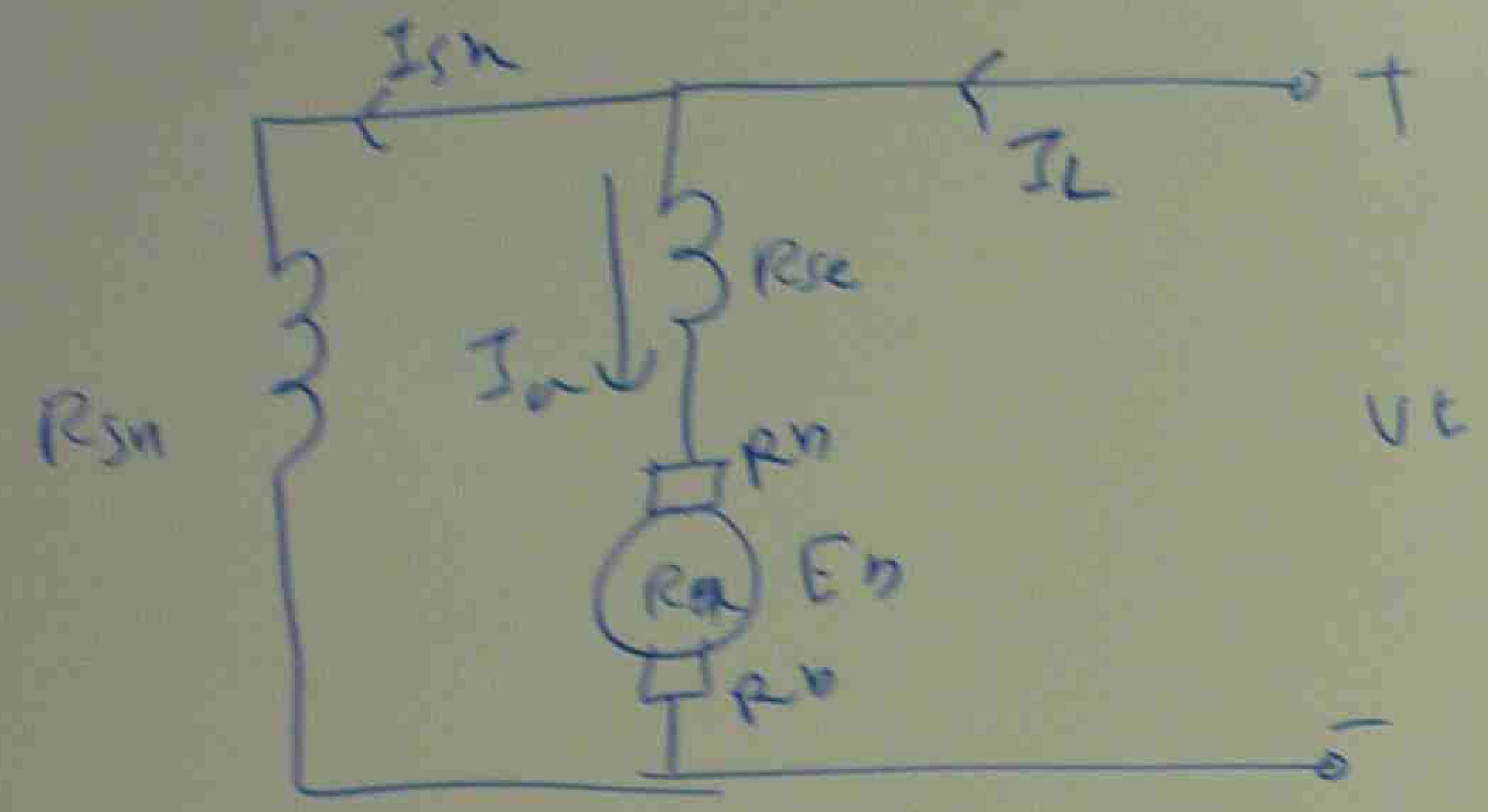
SHAFT
BEARING
YOKE
CONNECTION OF DC MACHINES
(A) SHUNT CONNECTION
SHUNT FIELD
CONSTANT VOLTAGE
ARMATURE
INTERPOLE
+
−
(B) SEPARATELY EXCITATION
FIELD
ARMATURE
INTERPOLE
+
−
(C) SERIES CONNECTION
SERIES FIELD
INTERPOLE
ARMATURE
+
−
VARYING TORQUE
FIELD COIL
(D) COMPOUND CONNECTION
SHUNT FIELD
SERIES FIELD
ARMATURE
INTERPOLE
+
−
GOOD FOR STABILITY

+ 2Rb)

t

2Rb)

LONG SHUNT COMPOUND MOTOR

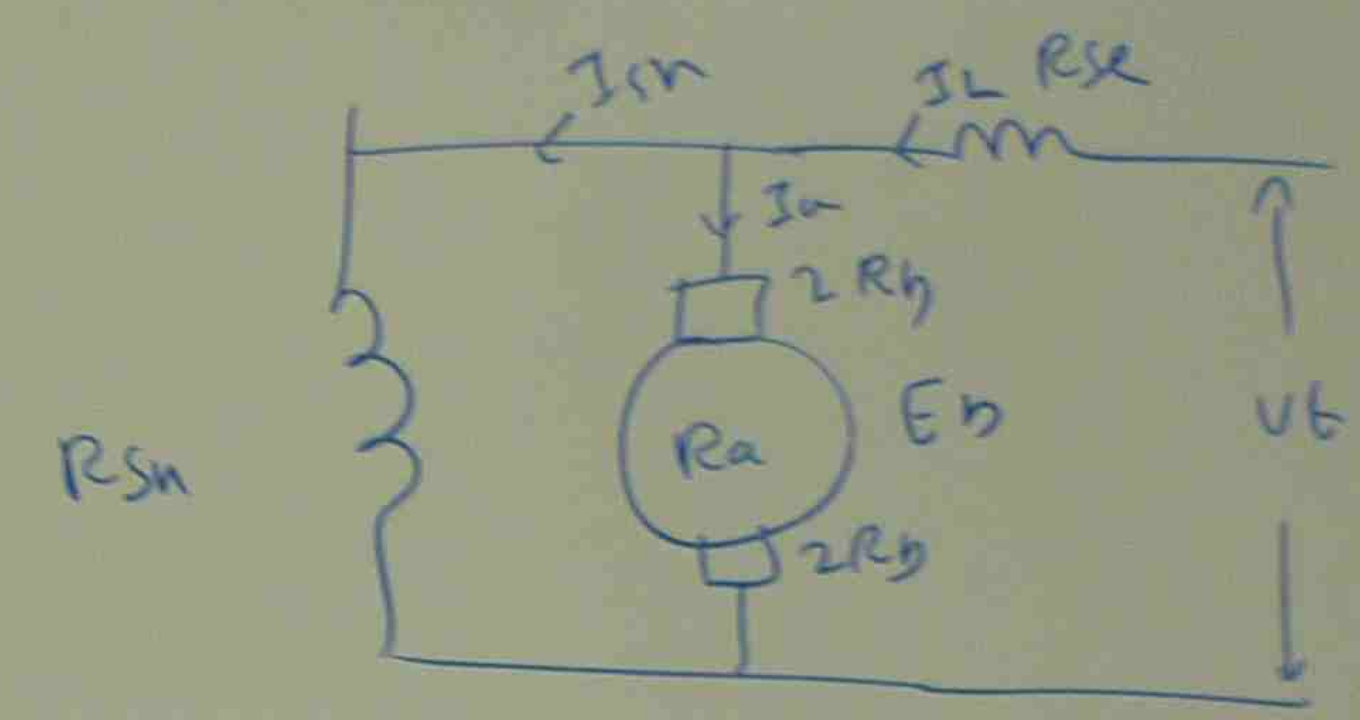


$$I_{sh} = \frac{V_t}{R_{sh}}$$

$$E_b = V_t - I_a(R_{se} + R_a + 2R_b)$$

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

SHORT SHUNT COMPOUND MOTOR



$$I_{sh} = \frac{V_t - I_L R_{se}}{R_{sh}}$$

$$E_b = V_t - (I_L R_{se} + I_a(R_a + 2R_b))$$

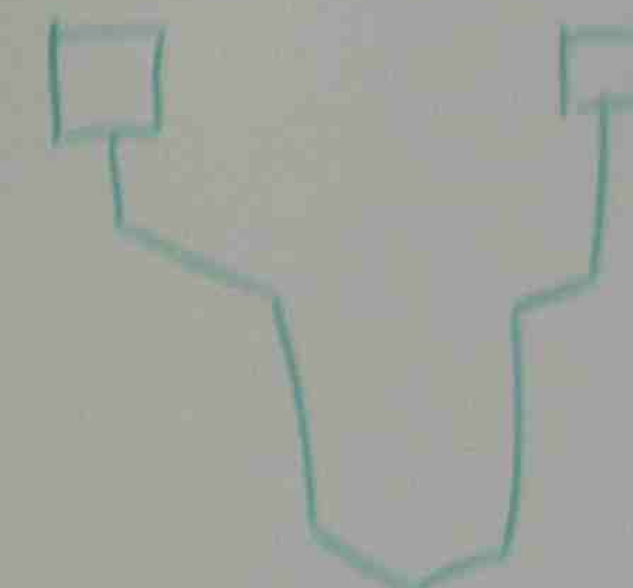
$$I_a = I_L - I_{sh}$$

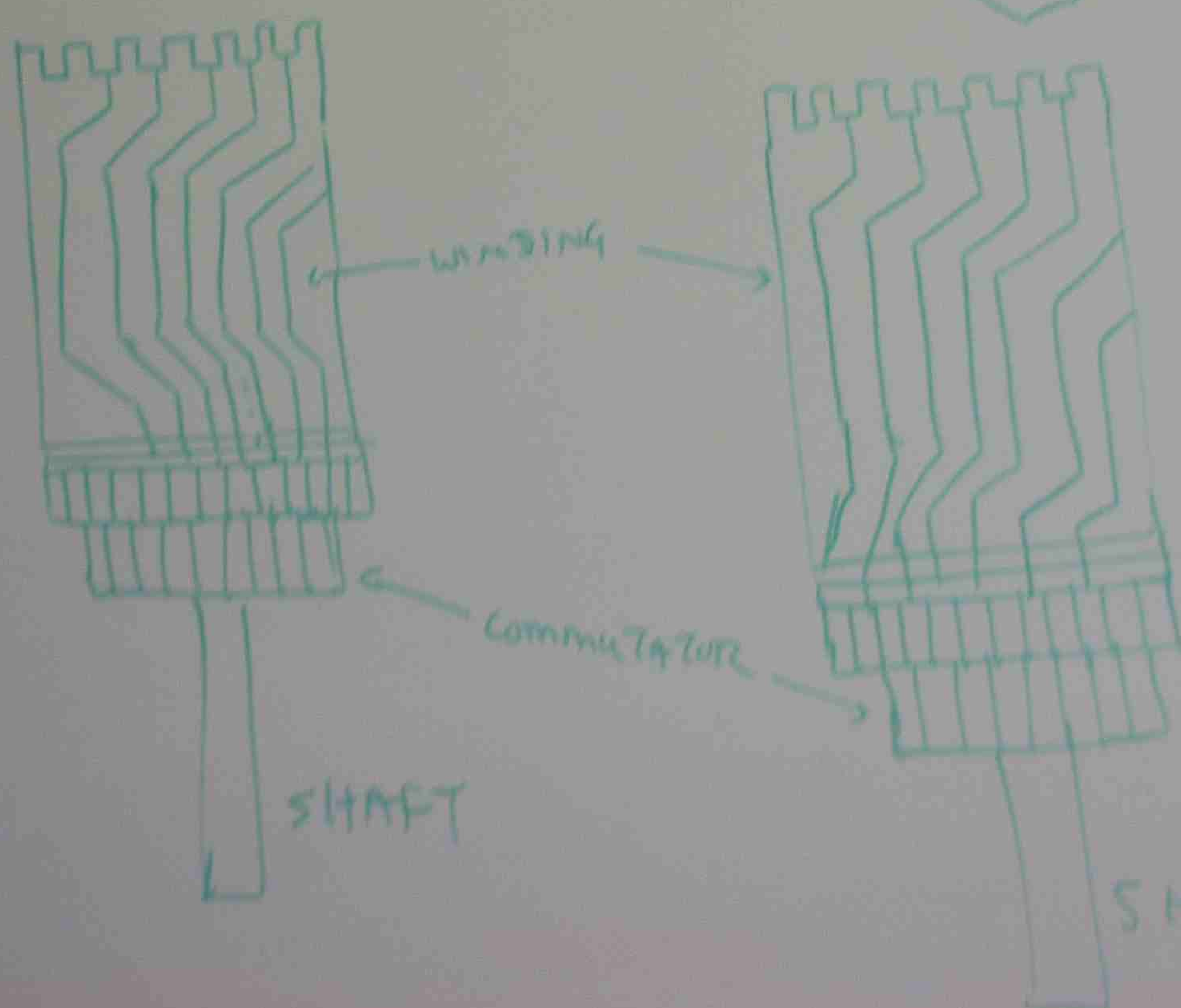
GO44

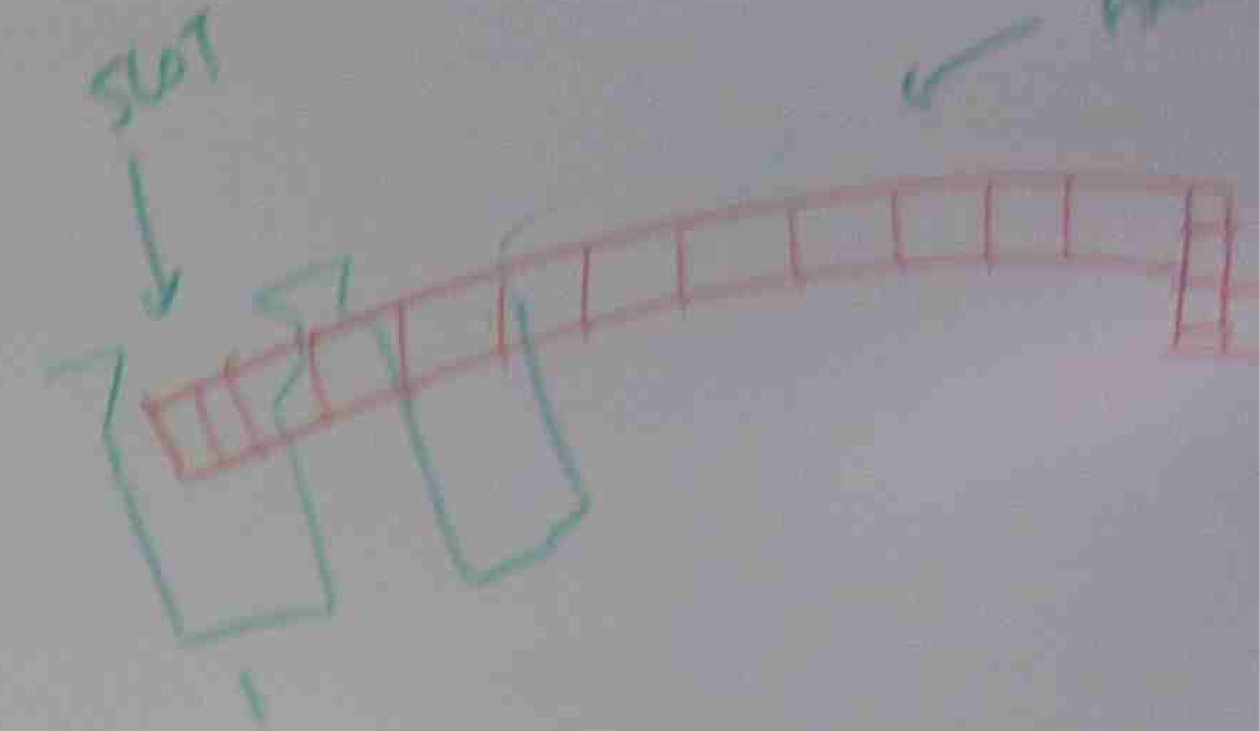
TYPES OF DC ARMATURE WINDINGS

LAPWINDING

WAVEWINDING







COIL PITCH

$$Y_1 = \frac{S}{P} \pm k$$

S = NO. OF SLOTS

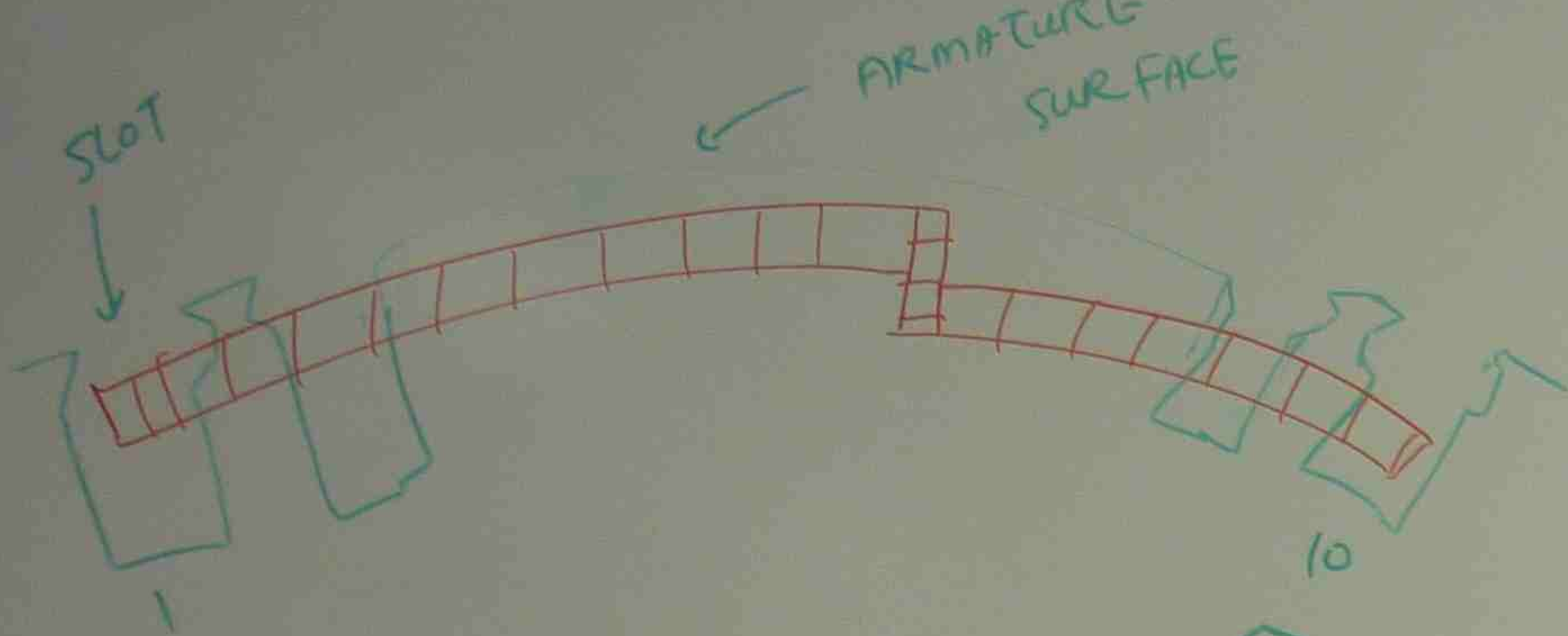
P = NO. OF POLES

k = A FRACTION

ADDED TO

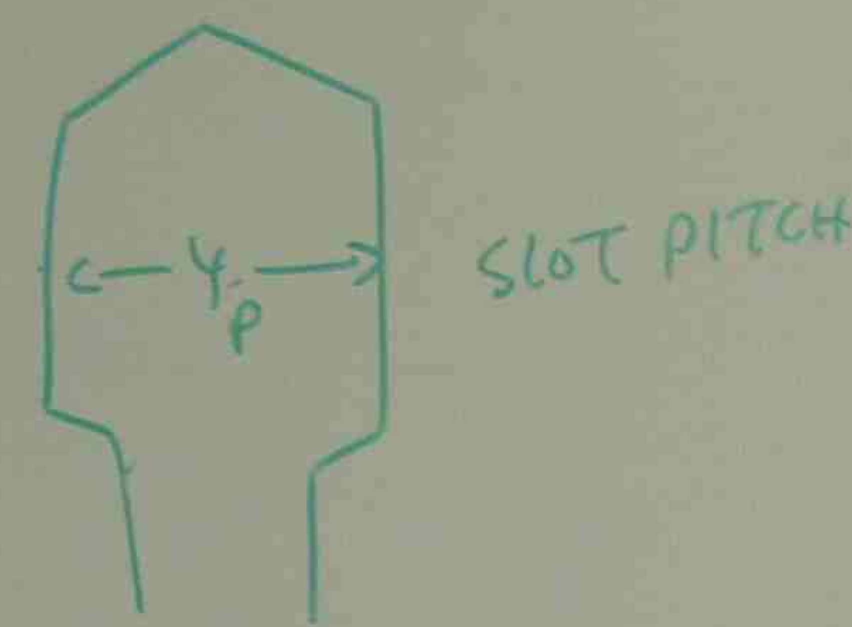
FROM $\frac{S}{P}$

INTEGER



COIL PITCH

$$Y_p = \frac{S}{P} \pm k$$



S = NO. OF SLOTS

P = NO. OF POLES

k = A FRACTION THAT IS EITHER ADDED TO OR SUBSTRACTED FROM $\frac{S}{P}$ TO MAKE Y_p TO BE INTEGER

pb CALCULATE THE COIL PITCH Y_p AND INDICATE THE SLOT NUMBERS IN WHICH THE FIRST COIL IS WOUND FOR EACH OF THE FOLLOWING CASES ASSUMING THAT THE DETAILS REFER TO A 4 POLE MACHINE.

(a) S = 35 (b) S = 36 (c) S = 37 (d) S = 42

(a) $Y_p = \frac{S}{P} = \frac{35}{4} = 8\frac{1}{4} - \frac{1}{4} = 8$ SLOT 1 → 9

(b) $Y_p = \frac{S}{P} = \frac{36}{4} = 9$ SLOT 1 → 10

(c) $Y_p = \frac{S}{P} = \frac{37}{4} = 9\frac{1}{4} - \frac{1}{4} = 9$ SLOT 1 → 10

(d) $Y_p = \frac{S}{P} = \frac{42}{4} = 10\frac{1}{2} - \frac{1}{2} = 10$ SLOT 1 → 11

p AND INDICATE THE SLOT
ST COIL IS WOUND FOR
ES ASSUMING THAT THE
OLE MACHINE.

(c) S=37 (d) S=42

$\frac{1}{4} - \frac{1}{4} = 8$

SLOT 1→9

SLOT 1→10

$\frac{1}{4} - \frac{1}{4} = 9$ SLOT 1→10

$0\frac{1}{2} - \frac{1}{2} = 10$

SLOT 1→11

PB

REPEAT THE ABOVE EXAMPLE FOR THE FOLLOWING CASES ASSUMING THAT IN EACH INSTANCE THE DATA REFERS TO A 6 POLE MACHINE.

(a) S = 72 (b) S = 37 (c) S = 77

(a) $Y = \frac{S}{P} = \frac{72}{6} = 12$

1 → 13

(b) $Y = \frac{S}{P} = \frac{37}{6}$

$= 6\frac{1}{6} - \frac{1}{6} = 6$

1 → 7

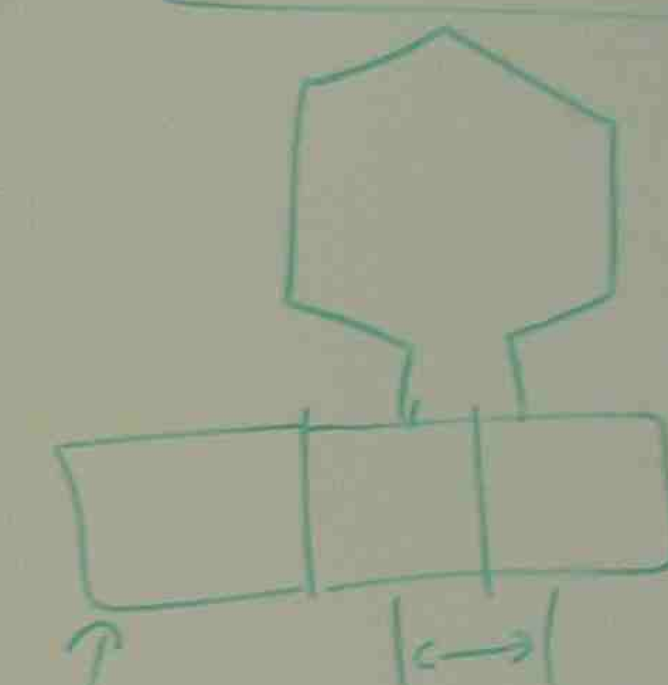
(c) $Y = \frac{S}{P} = \frac{77}{6}$

$12\frac{5}{6} - \frac{5}{6}$

12

1 → 13

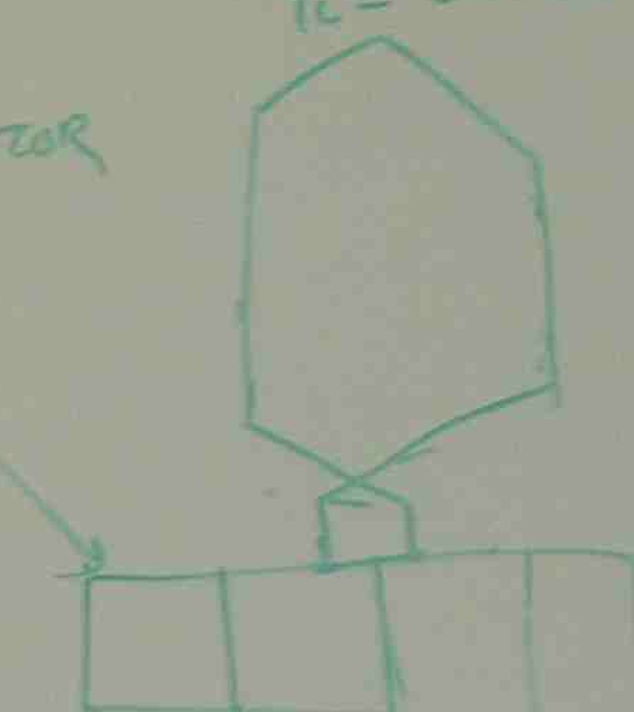
PROGRESSIVE AND RETROGRESSIVE WINDINGS



PROGRESSIVE

Y_c = COMMUTATOR PITCH = +1 FOR SIMPLEX LAP PROGRESSIVE WINDING

COMMUTATOR



Y_c = COMMUTATOR PITCH = −1 FOR SIMPLEX LAP RETROGRESSIVE WINDING

WAVE WINDING

IN SIMPLEX WAVE WINDING, THE CIRCUIT RETURNS TO A SEGMENT ADJACENT TO THE STARTING SEGMENT AFTER TRANSVERSING $\frac{P}{2}$ COILS

$$Y_c = \frac{C \pm m}{P/2}$$

C = NO OF COMMUTATOR SEGMENT

m = 1 FOR SIMPLEX WAVE
2 FOR DUPLEX WAVE

+ PROGRESSIVE
− RETROGRESSIVE

P = NO. OF POLES.

Pb FIND THE COMMUTATOR PITCH OF THE FOLLOWING WINDINGS 4 POLES

(a) 35 SLOTS, SIMPLEX WAVE PROGRESSIVE
(b) 35 SLOTS SIMPLEX WAVE RETROGRESSIVE
(c) 34 SLOTS DUPLEX WAVE PROGRESSIVE
(d) 34 SLOTS DUPLEX WAVE RETROGRESSIVE

(a) $Y_c = \frac{C \pm m}{P/2} = \frac{35+1}{4/2} = \frac{36}{2} = 18$

$1 \rightarrow 19$

(b) $Y_c = \frac{C \pm m}{P/2} = \frac{35-1}{4/2} = \frac{34}{2} = 17$

$1 \rightarrow 18$

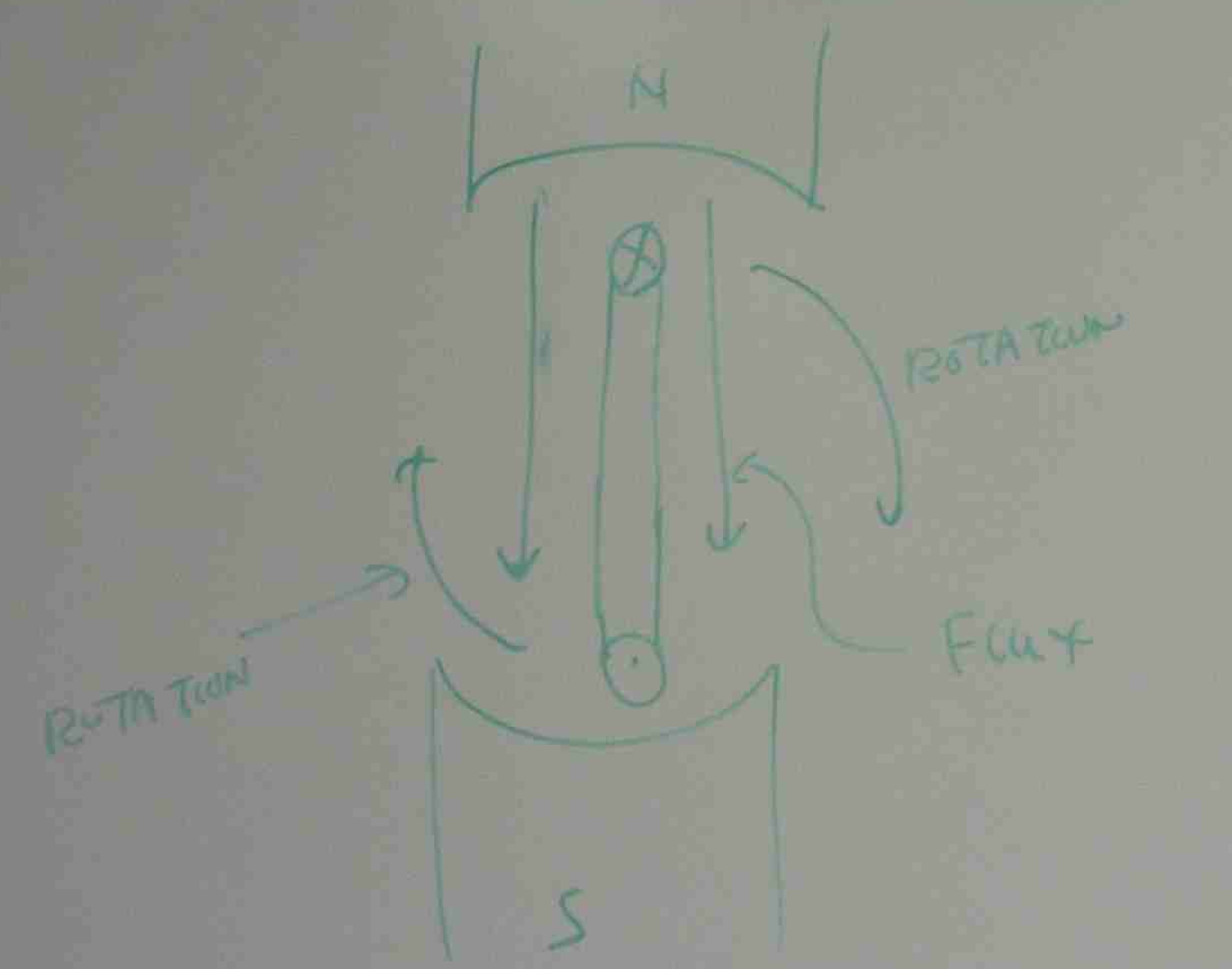
(c) $Y_c = \frac{C \pm m}{P/2} = \frac{34+2}{4/2} = \frac{36}{2} = 18$

$1 \rightarrow 19$

(d) $\frac{34-2}{4/2}$

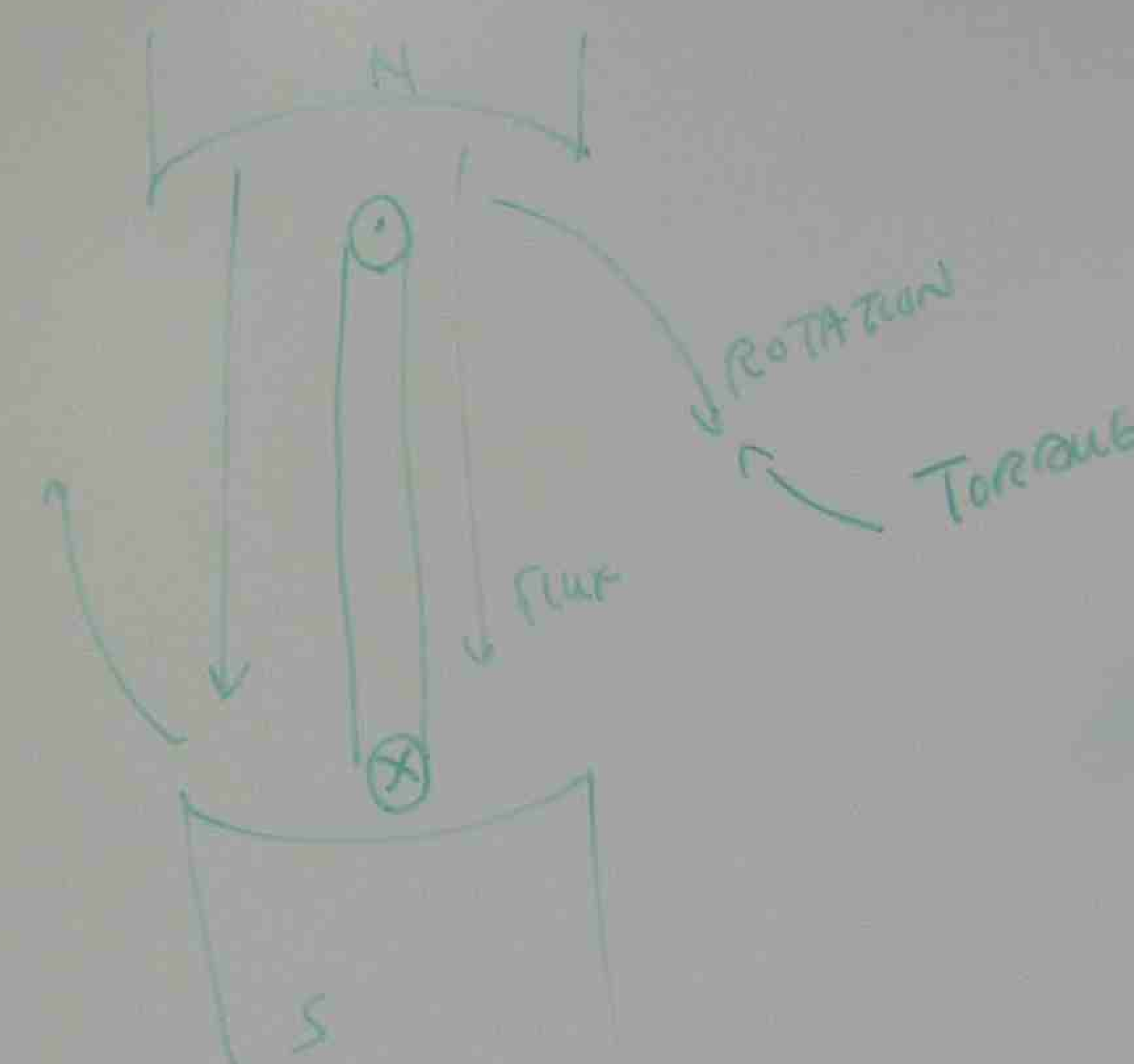
$\frac{32}{2} =$

MECHANICAL ACTION OF DC GENERATOR AND MOTOR



⊗ ⊙ CURRENT DIRECTION

GENERATOR ACTION



MOTOR ACTION

$$\boxed{T = I\alpha}$$

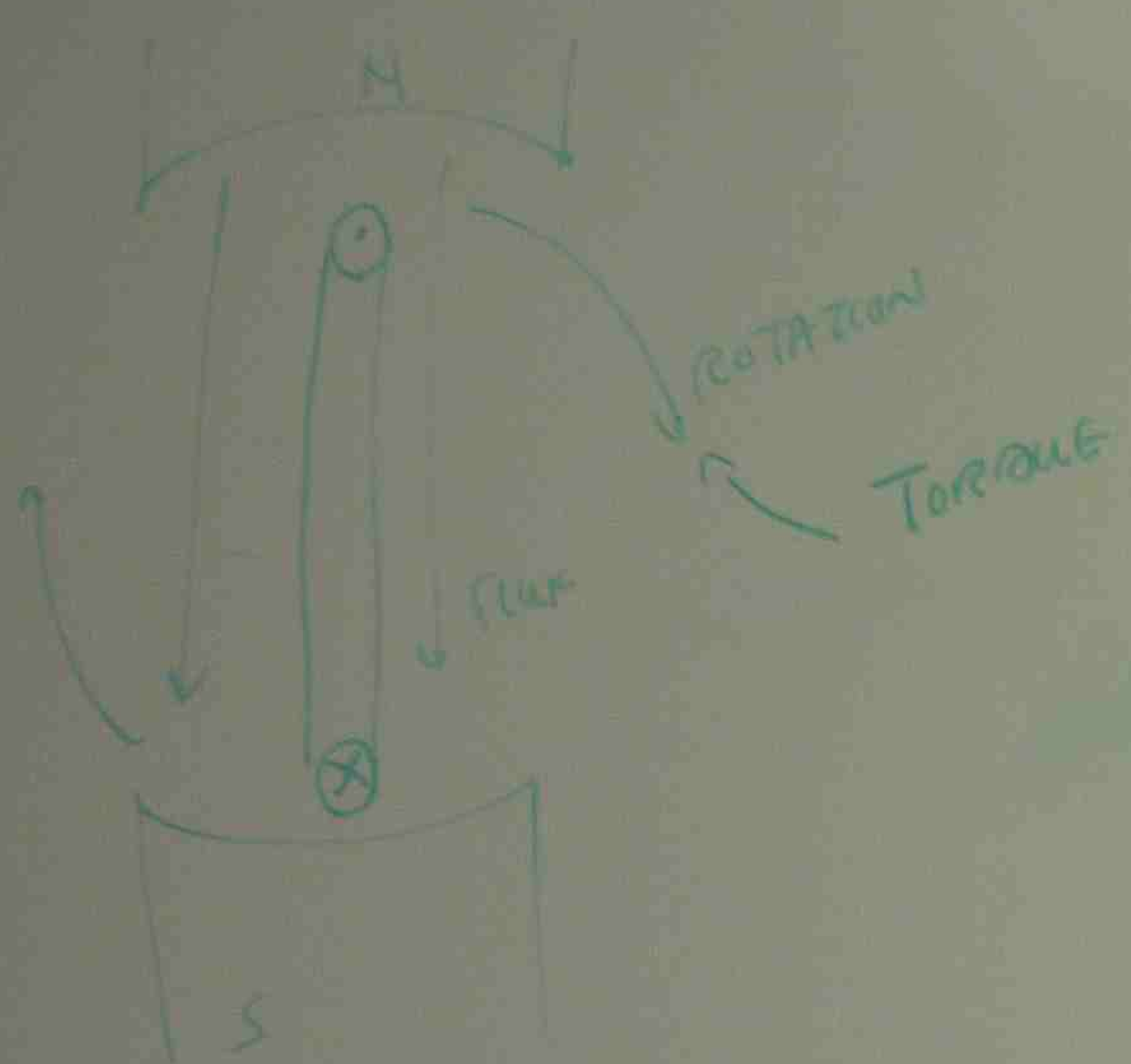
pb A MOTOR
OF 10 N

200 RAD

THE MOTOR

CALCULATE (

GENERATOR AND MOTOR



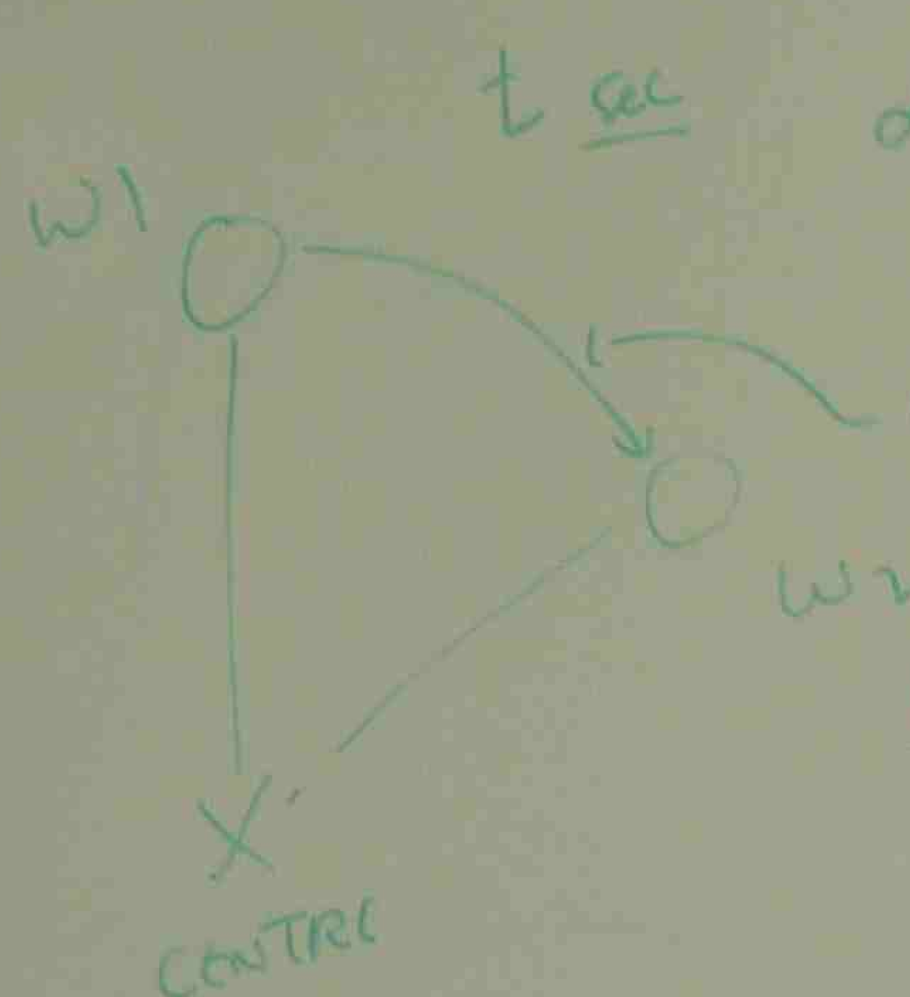
MOTOR ACTION

$$\boxed{T = I\alpha}$$

T = TORQUE N-m

I = MOMENT OF INERTIA $N\text{-}m/s^2$

α = ANGULAR ACCELERATION RAD/s^2



ω = ANGULAR VELOCITY RAD/s

$$\boxed{\omega_2 = \omega_1 + \alpha t}$$

pb

A MOTOR HAS A COMBINED MOMENT OF INERTIA OF $10\ N\text{-}m/s^2$ AND INITIAL VELOCITY OF $200\ RAD/s$. IF THE TORQUE PRODUCED BY THE MOTOR IS INCREASED BY 50N-m CALCULATE (a) THE TIME FOR THE SPEED TO REACH $300\ RAD/s$

(b) THE FINAL SP

(c) THE TORQUE

OF 50 RA

$I = 10\ N-$

$T = 50\ N$

(a) ω

$T = I$

$50 = 10$

$\alpha = \frac{50}{1}$

T = TORQUE N-m

I = MOMENT OF INERTIA N-m/s^2

α = ANGULAR ACCELERATION RAD/s^2

ω = ANGULAR VELOCITY RAD/s

$$\boxed{\omega_2 = \omega_1 + \alpha t}$$

... A COMBINED MOMENT OF INERTIA

.../s^2 AND INITIAL VELOCITY OF

... IF THE TORQUE PRODUCED BY

... INCREASED BY 50 N-m

... TIME FOR THE SPEED TO REACH

... 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/SEC IN 2.5 SEC.

$I = 10$ N-m/s^2 $\omega_1 = 200$ RAD/s

$T = 50$ N-m $\omega_2 = 300$ RAD/s

$t = ?$

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

$$T = I\alpha$$

$$50 = 10\alpha$$

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

$$\omega_2 = \omega_1 + \alpha t$$

$$300 = 200 + 5 \times t$$

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

$$= \frac{100}{5} = 20 \text{ SEC}$$

(b) t ...

$\omega_2 = \omega$ ...

= 2 ...

= ...

(c) ...

α ...

$T =$ ...

(b) $t = 10\text{ sec}$

$\omega_2 = ?$

$\omega_2 = \omega_1 + \alpha t$

$= 200 + 5 \times 10$

$= 250$ RAD/s

(c) $\omega_2 - \omega_1 = 50$ RAD/s

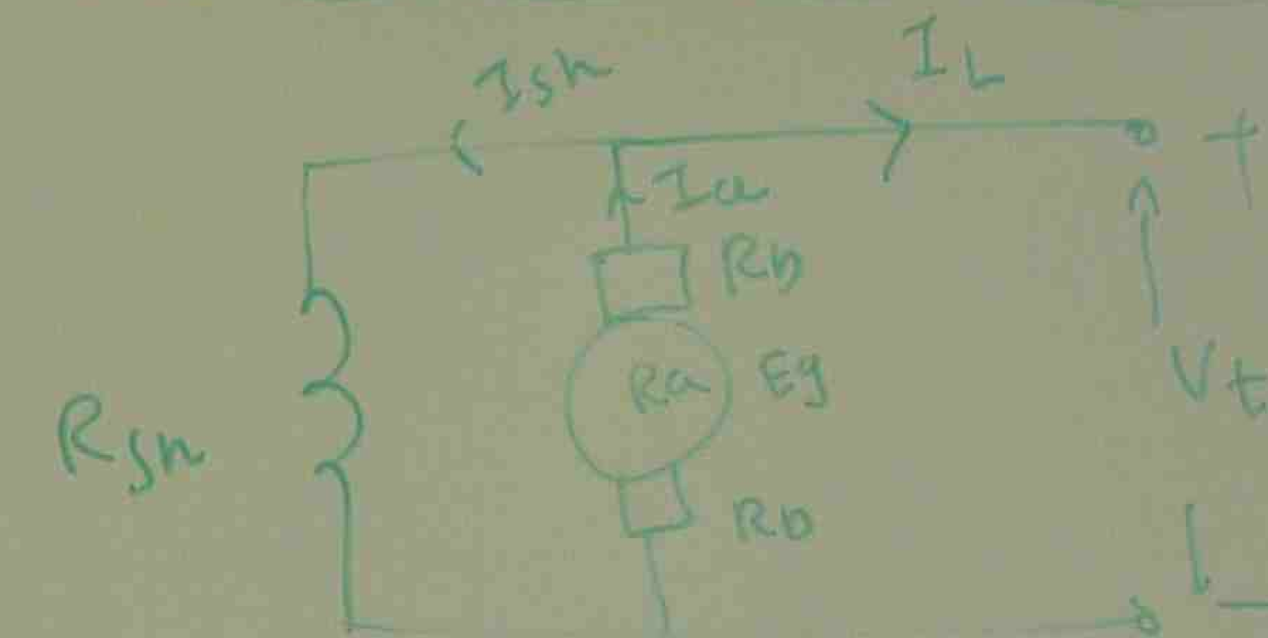
$t = 2.5$ sec

$T = ?$

$$\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{50}{2.5} = 20 \text{ RAD/s}^2$$

$$T = I\alpha = 10 \times 20 = 200 \text{ N-m}$$

CONFIGURATION OF DC MACHINE WINDINGS



SHUNT GENERATOR

R_{sh} = SHUNT FIELD RESISTANCE

R_a = ARMATURE RESISTANCE

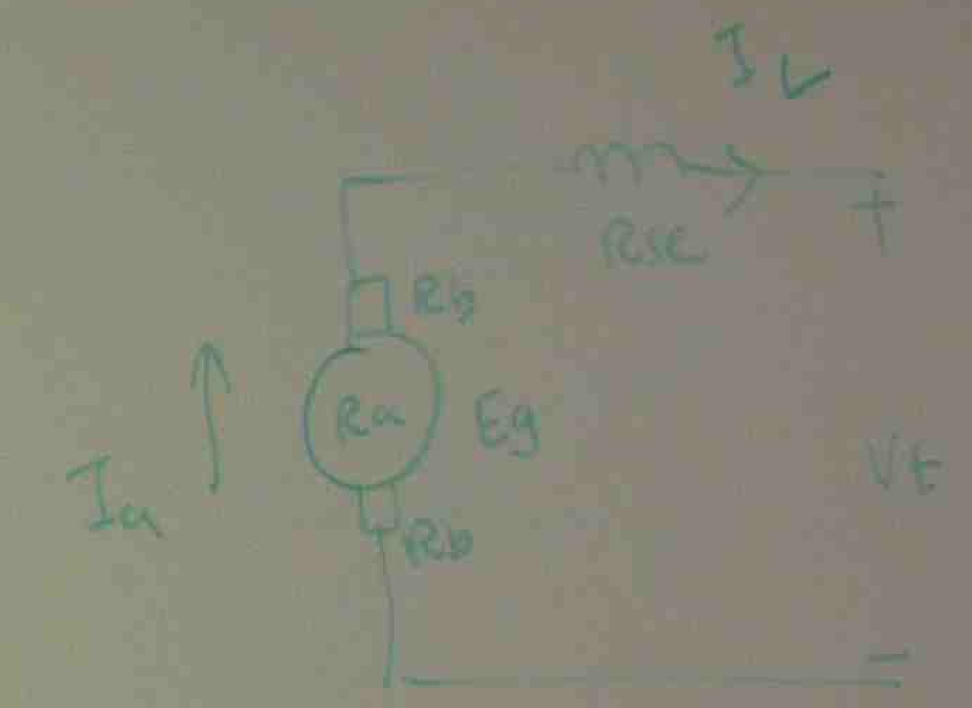
R_b = BRUSH RESISTANCE

E_g = GENERATED VOLTAGE

V_t = TERMINAL VOLTAGE

$I_a = I_L + I_{sh}$ $\quad E_g = V_t + I_a(R_a + 2R_b)$

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



SERIES GENERATOR

$I_a = I_L$

$E_g = V_t + I_L($

$$I_L = \frac{\text{LOAD POW}}{V_t}$$

MACHINE WINDINGS

RATOR

ESISTANCE

RESISTANCE

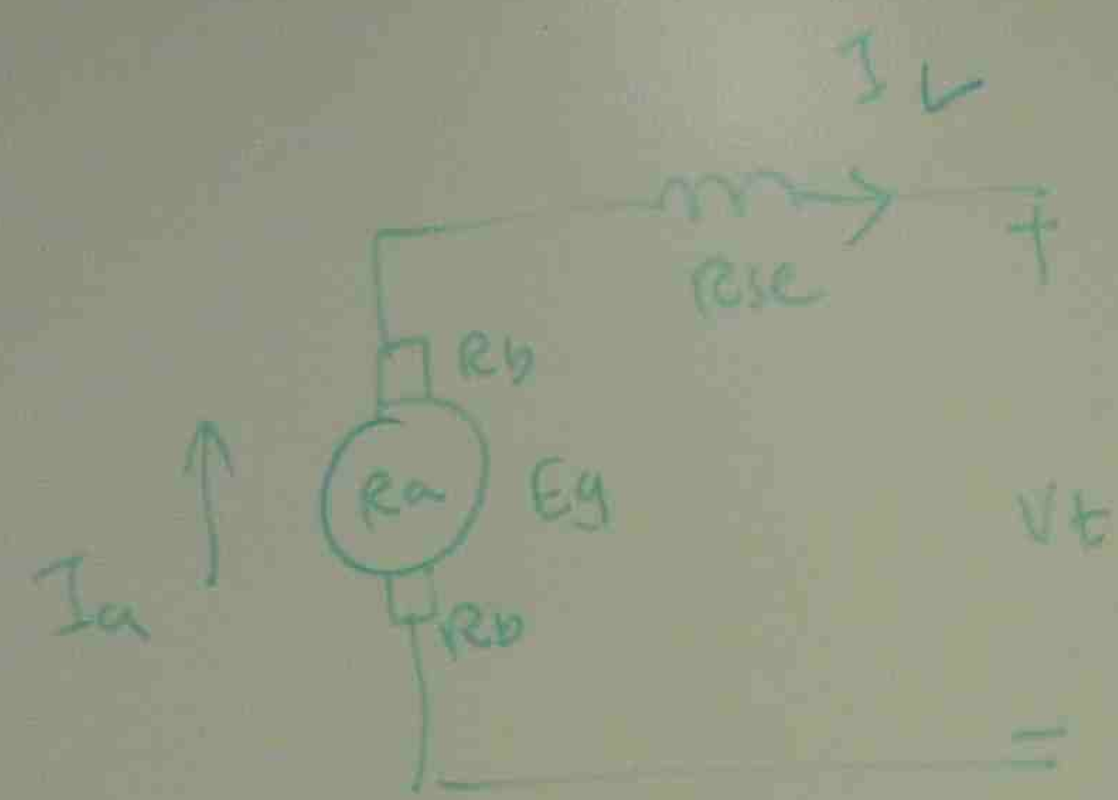
ANCE

OLTAGE

OLTAGE

sh

$E_g = V_t + I_a(R_a + 2R_b)$



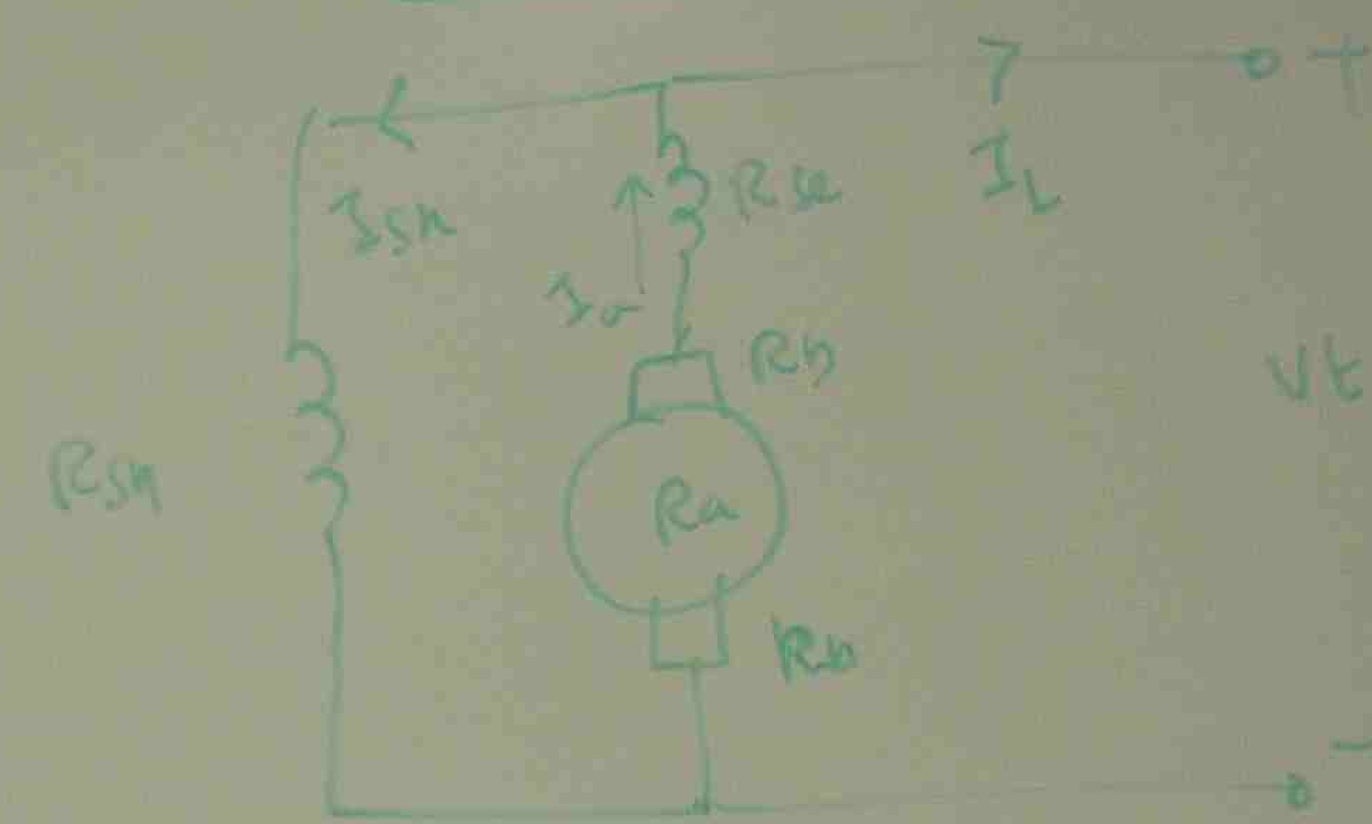
SERIES GENERATOR

$I_a = I_L$

$E_g = V_t + I_L(R_{se} + R_a + 2R_b)$

$I_L = \frac{\text{LOAD POWER}}{V_t}$

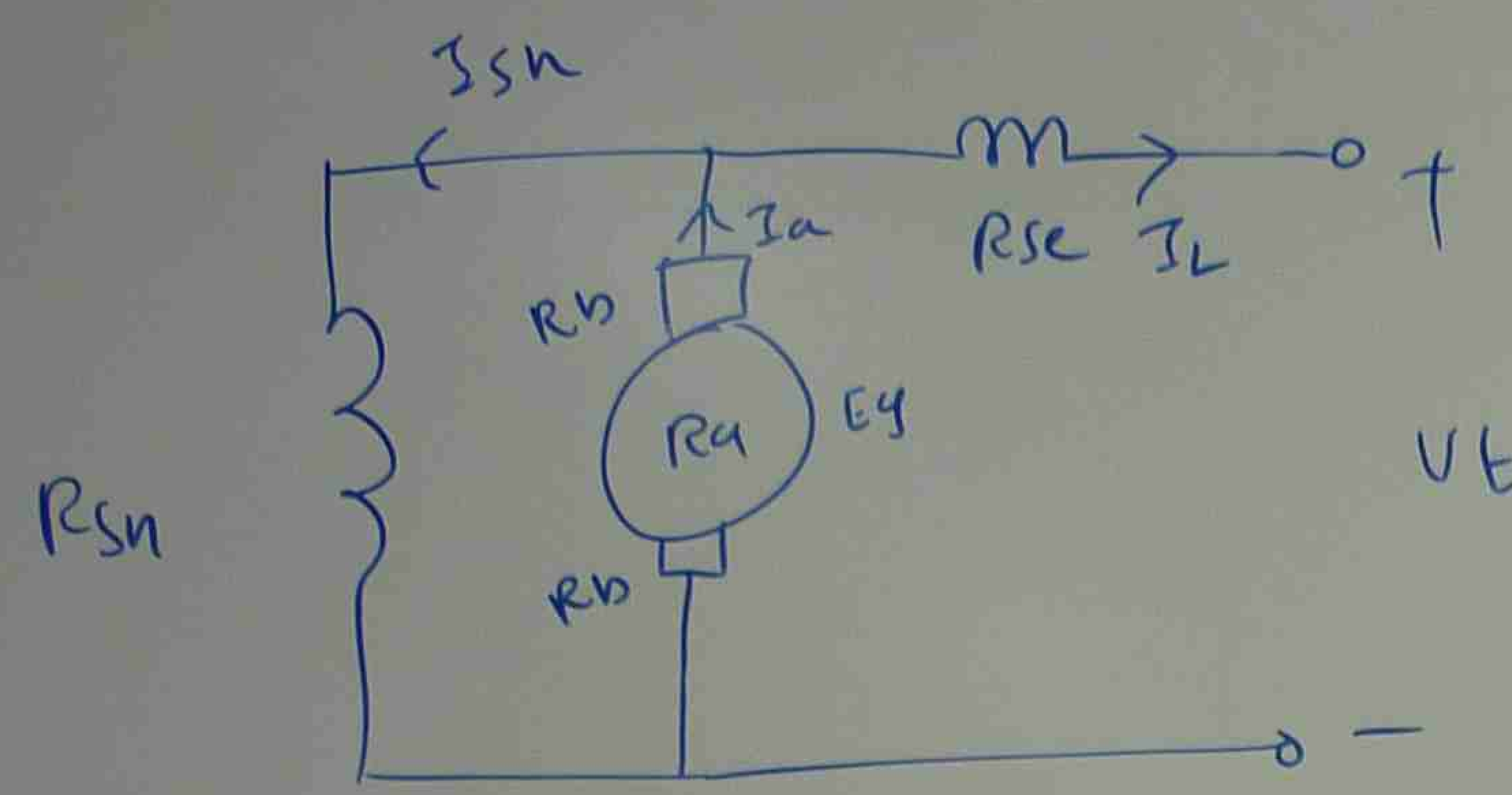
LONG SHUNT COMPOUND GENERATOR



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

$I_a = I_{sh} + I_L$

$E_g = V_t + I_a(R_{se} + R_a + 2R_b)$



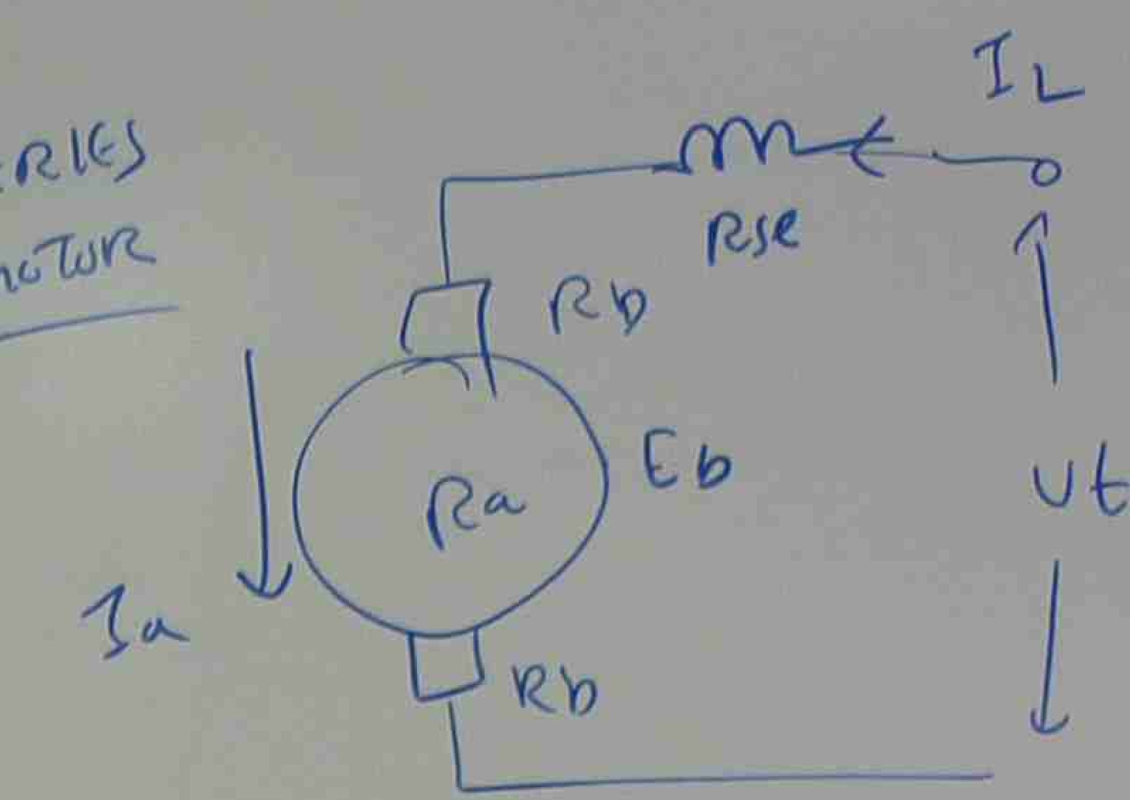
SHORT SHUNT COMPOUND

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

$$I_{sh} = \frac{V_t + I_L R_{se}}{R_{sh}}$$

$$E_g = V_t + I_a (R_a + 2R_b)$$

SERIES MOTOR

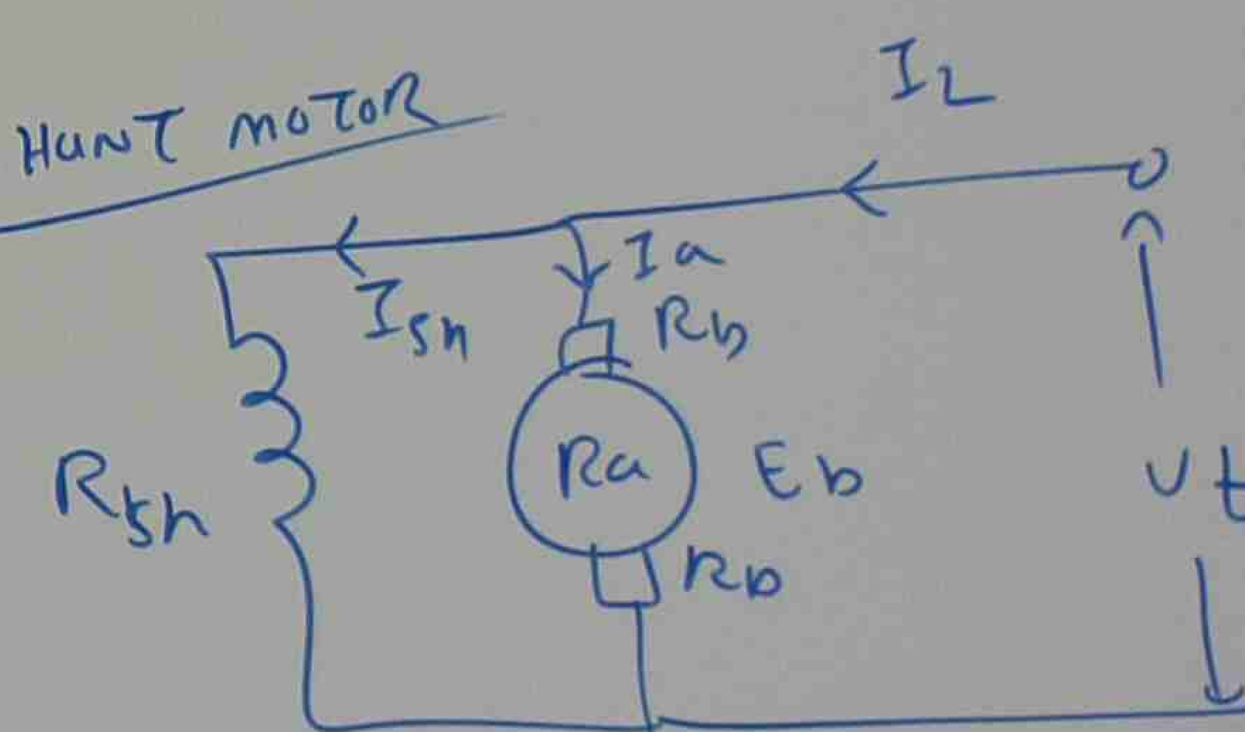


E_b = BACK EMF

$I_L = I_a$

$$E_b = V_t - I_a (R_a + 2R_b)$$

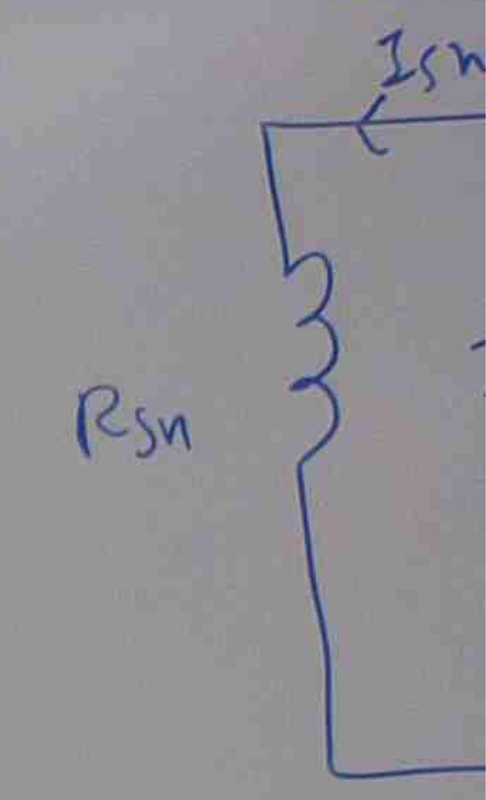
SHUNT MOTOR



$$I_{sh} = \frac{V_t}{R_{sh}}, \quad E_b = V_t - I_a (R_a + 2R_b)$$

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

LONG



e_com

G043 + G045

7762AF

043_G045_7762AF Notes 1

043_G045_7762AF Notes 2

S_ G046_ G040_ G043_ G045_G042 Tutorial

62AA

AC

AG

7762AE

7762AD

7762AF

7762AH

4269T

GENERATED VOLTAGE + BACK EMF

$$E_g = \frac{\phi Z N}{60} \times \frac{P}{a} \quad \text{(GENERATOR)}$$

E_g = GENERATED VOLTAGE

Z = NO. of CONDUCTORS

N = RPM

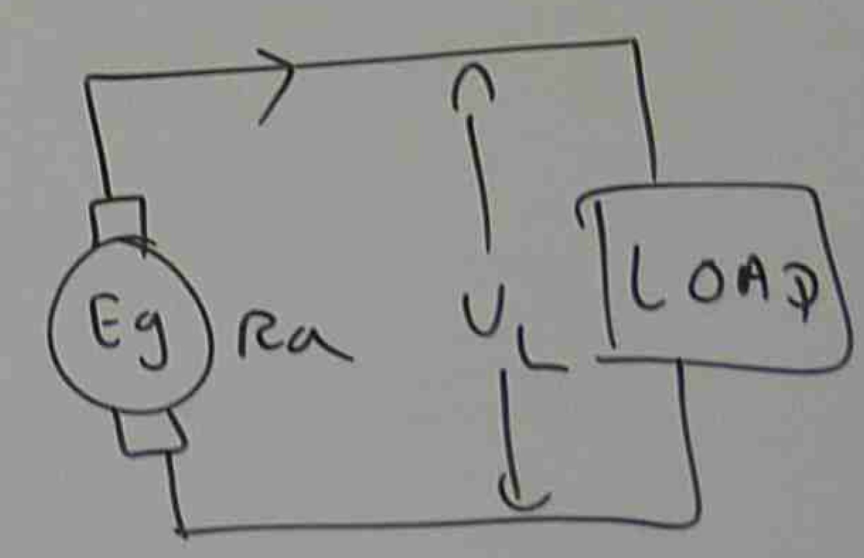
P = NO. of POLES

a = NO. of ARMATURE PARALLEL PATHS

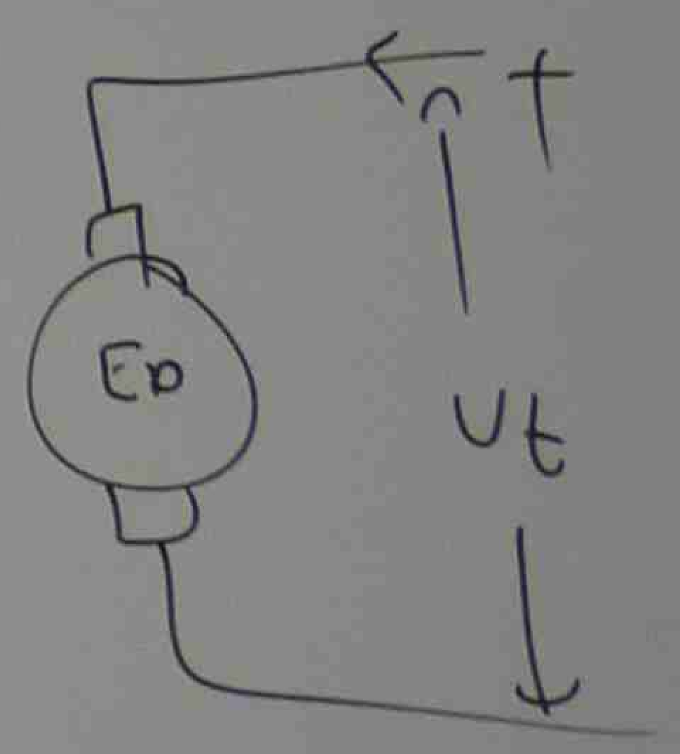
$a = m \times P$ (LAP)

$a = m \times 2$ (WAVE)

$$E_b = \frac{\phi Z N}{60} \times \frac{P}{a} \quad \text{(MOTOR)}$$

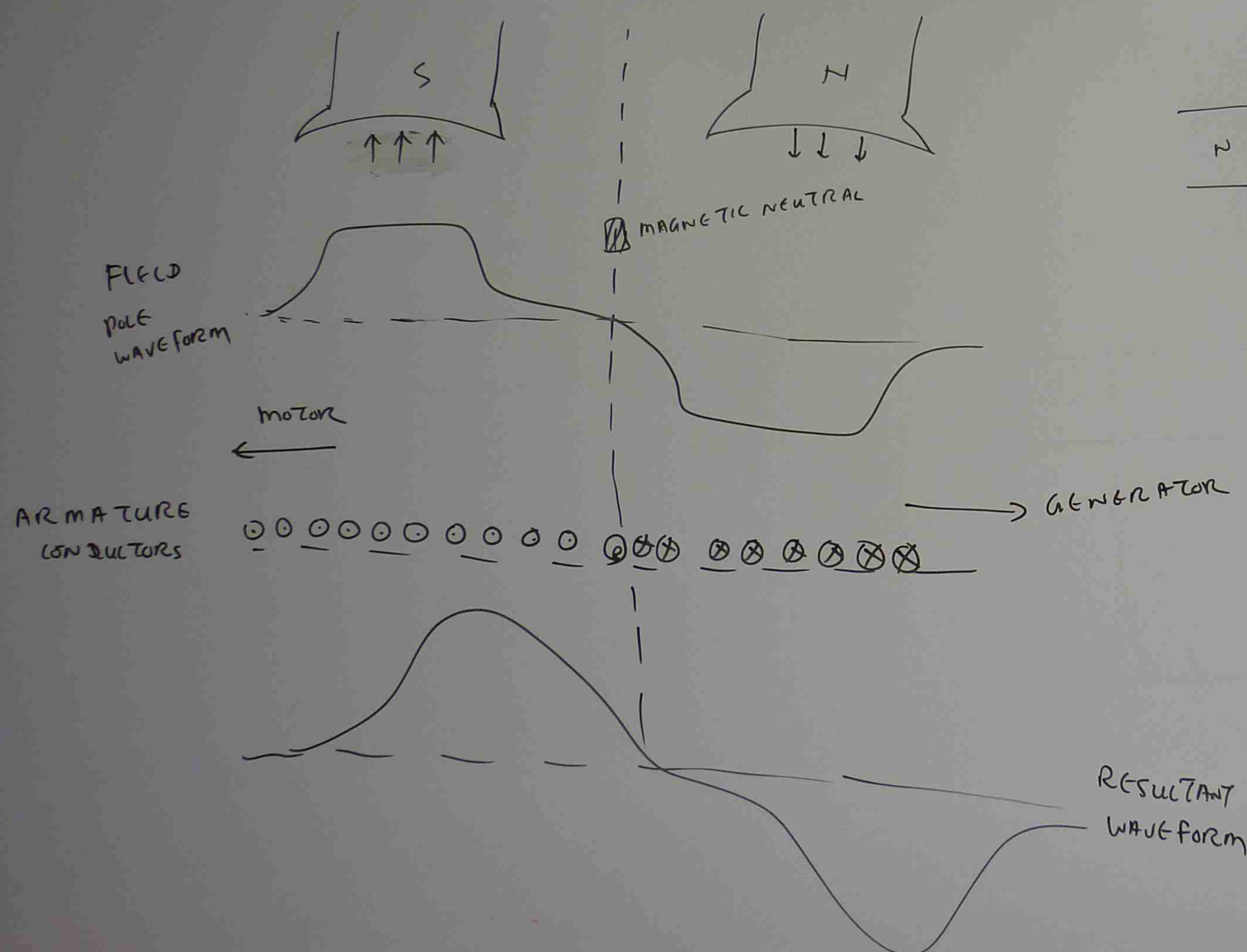


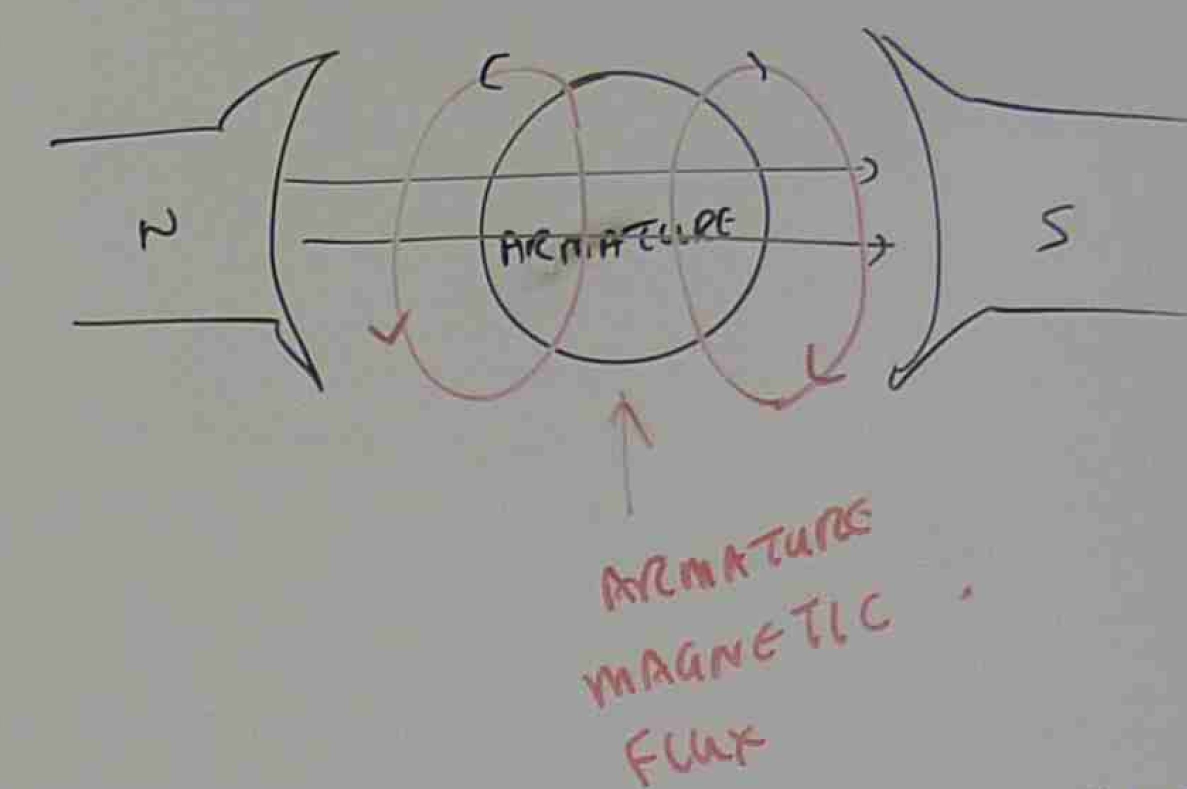
GENERATOR



MOTOR

MAGNETIC ACTION OF ARMATURE FIELD DISTORTION





(ATc)

UNIT

ARMATURE REACTION
- OPPOSING MAIN FIELD FLUX → DEMAGNETIZING FLUX
- CROSSING MAIN FIELD FLUX → CROSS MAGNETIZING FLUX

ARMATURE REACTION → EFFECTS GENERATED VOLTAGE & TORQUE

...ING
... FIELD FLUX $\longrightarrow$ DEMAGNETIZING Flux

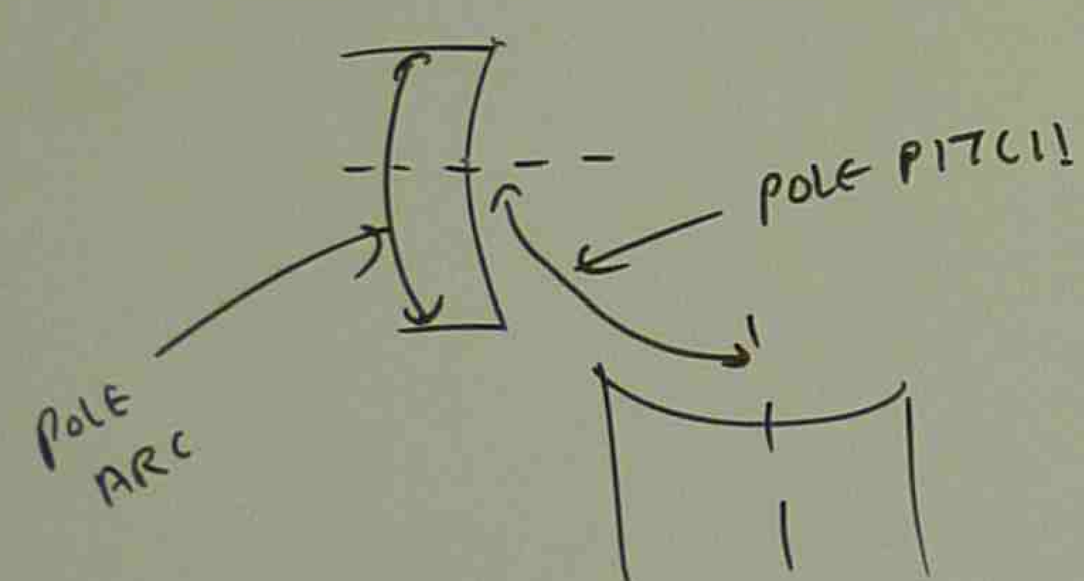
...OSSING
... IN FIELD
FLUX $\longrightarrow$ CROSS MAGNETIZING FLUX

...ERATED
... TORQUE

(ATc) CROSS MAGNETIZING Flux $= \dfrac{\gamma Z I_a}{2 a P}$

UNIT $\longrightarrow$ (Amp-Turns/pole)

$$\gamma = \frac{\text{Pole arc}}{\text{Pole pitch}}$$



Z = No. of armature conductors

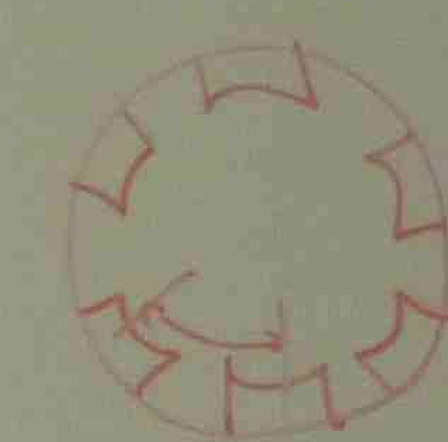
a = No. of armature parallel paths

P = No. of poles.

pb

An armature 0.5m diameter of 6 poles lap wound generator has 378 conductors carries 800 amp and has a pole arc 0.17m. Calculate cross magnetizing armature reaction ampere turn. simplex (lap)

$$AT_c = \frac{\gamma Z I_a}{2 a P}$$



$$\gamma = \frac{\text{Pole arc}}{\text{Pole pitch}}$$

$$= \frac{0.17}{\frac{\pi D}{\text{No. of poles}}}$$

$$= \frac{0.17}{\frac{3.1416 \times 0.5}{6}} = 0.65$$

a = ?

a =

$AT_c =$

=

E 0.5m DIAMETER OF
ND GENERATOR HAS 378
ES 800 AMP AND HAS
17mm. CALCULATE
ARMATURE REACTION

SIMPLEX (LAP)

Ia

P

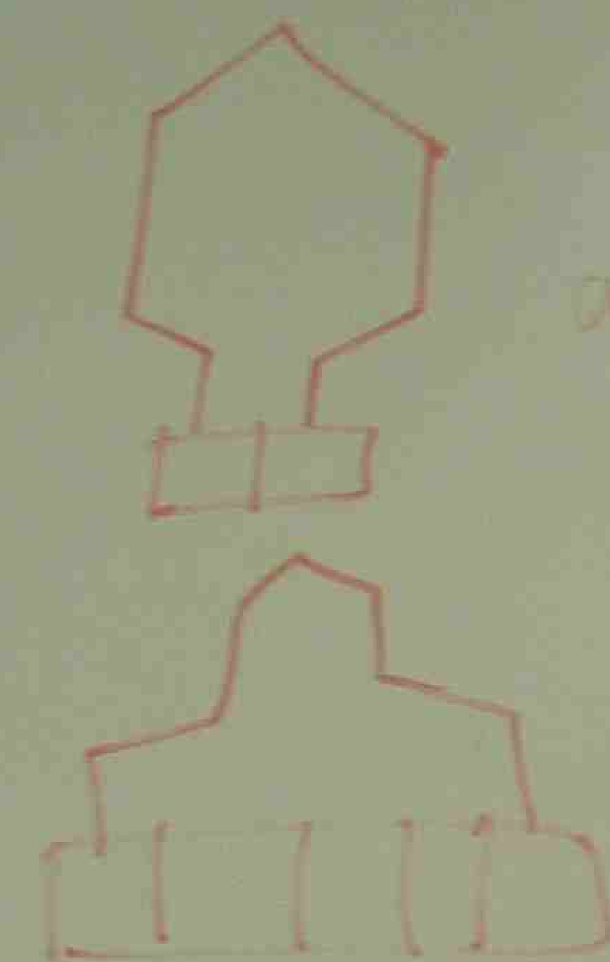
H

POLES

= 0.65

0.5

$a = ?$ — LAP / WAVE



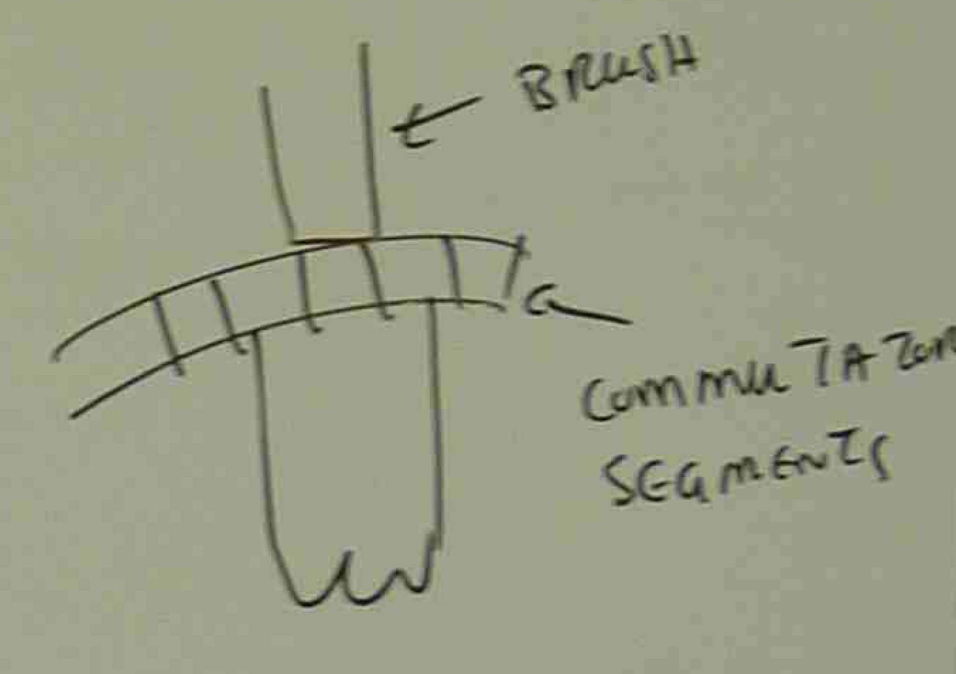
$a = m \times P$ — $m = 1$ SIMPLEX, $m = 2$ DUPLEX

$a = 2m$ — $m = 1$ SIMPLEX, $m = 2$ DUPLEX

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

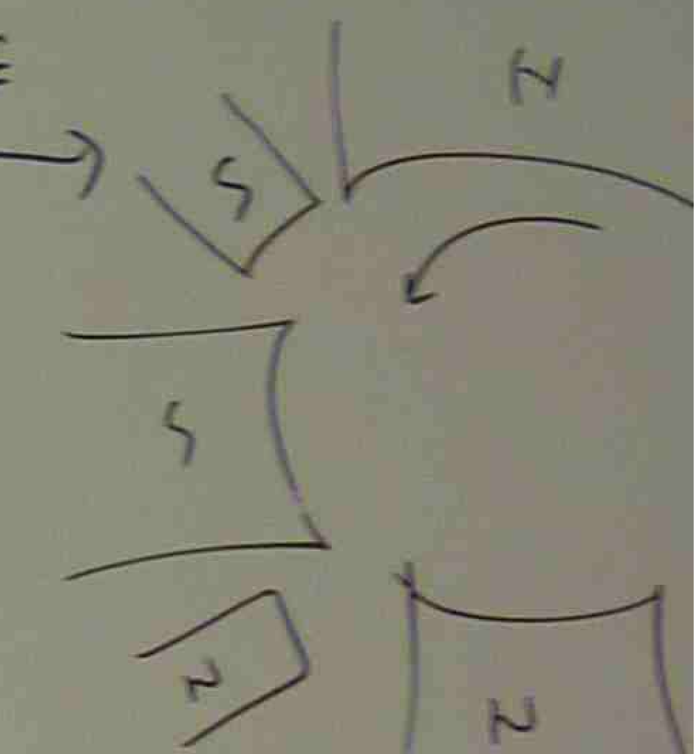
$$AT_c = \frac{0.65 \times 378 \times 800}{2 \times 6 \times 6}$$

$$= 2740 \ AT/\text{pole}$$

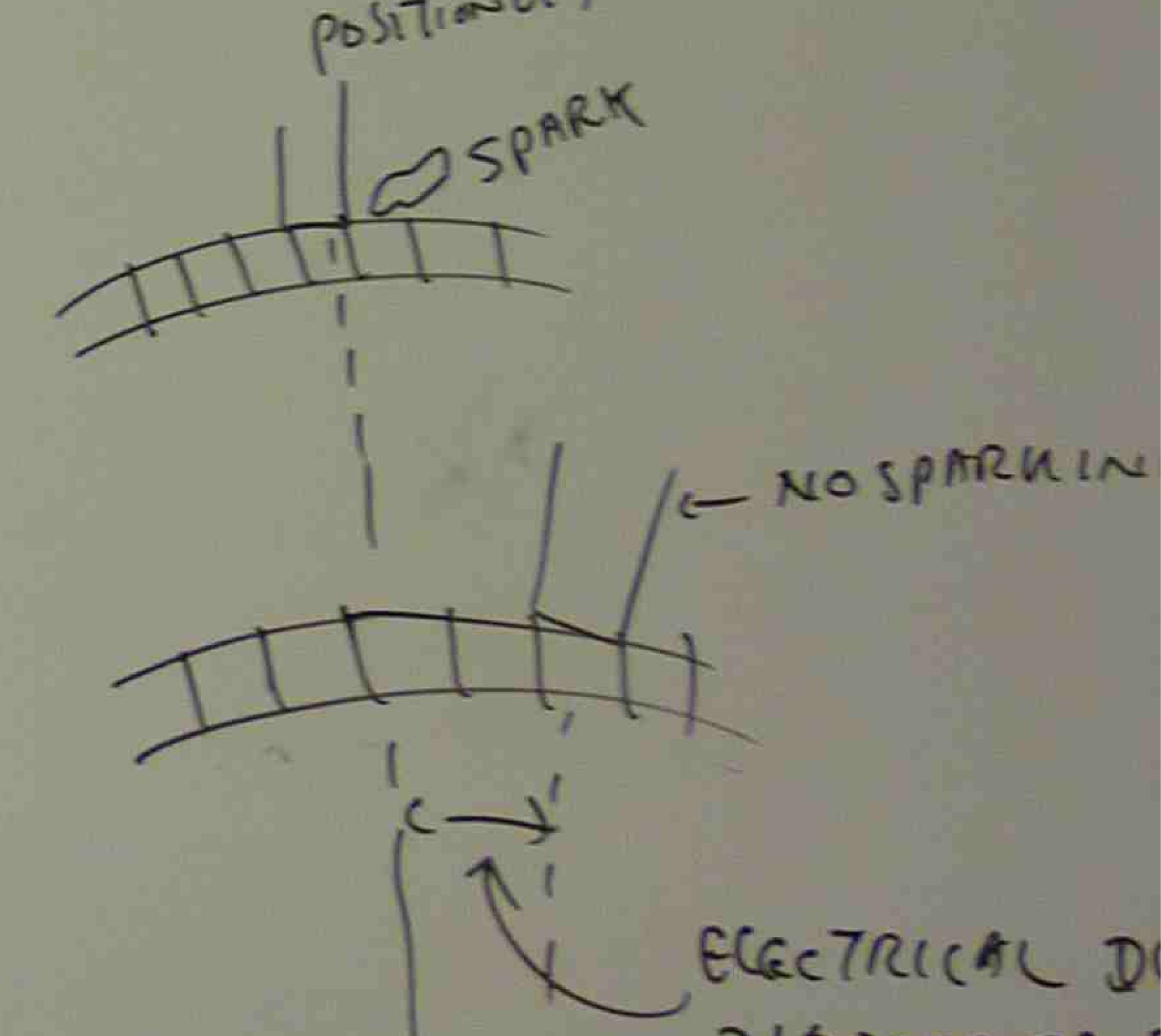


METHODS TO REDUCE ARMATURE

(1) INTER POLE



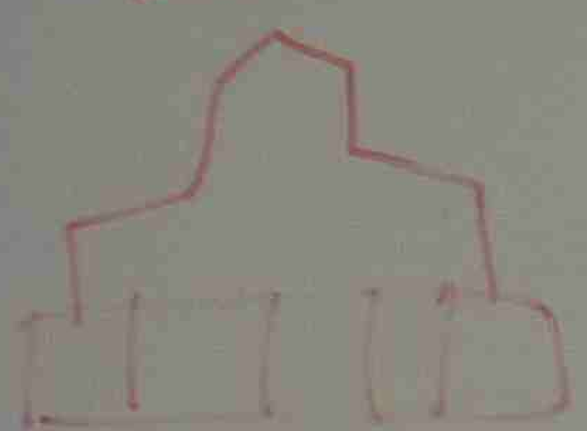
(2) SHIFT THE BRUSH



$a = m \times P$

$m = 1$ SIMPLEX

$m = 2$ DUPLEX



$a = 2m$

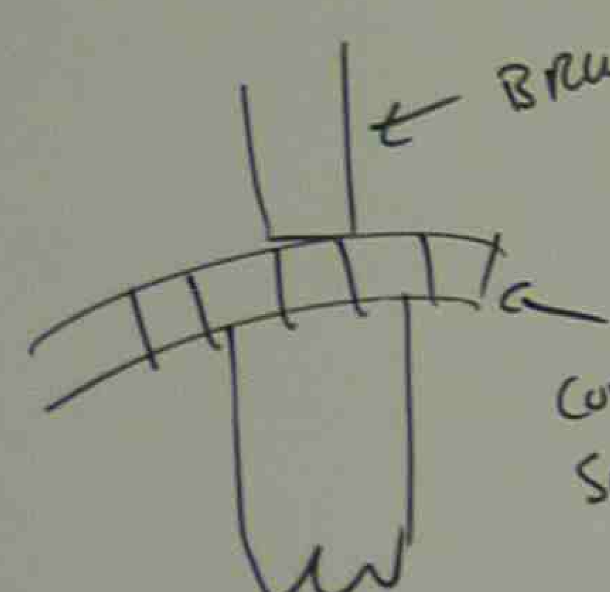
$m = 1$ SIMPLEX

$m = 2$ DUPLEX

$\times 6 = 6$

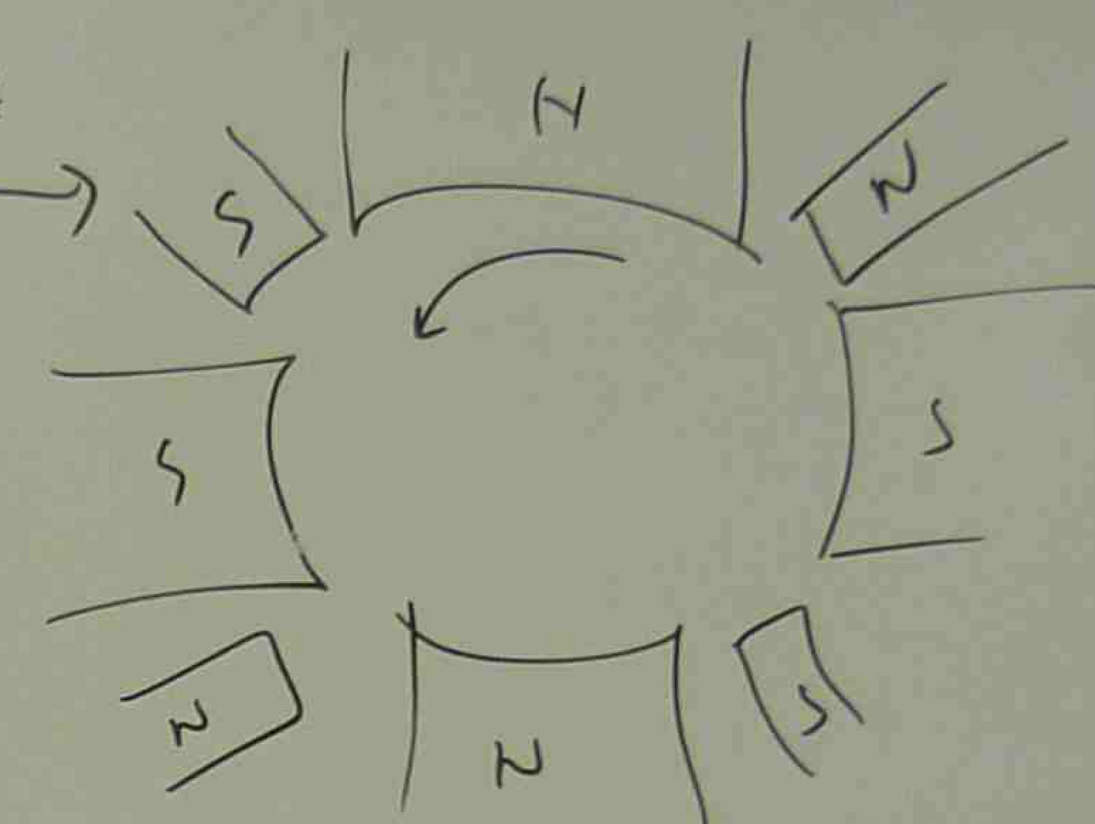
$\frac{78 \times 800}{6}$

AT / POLE

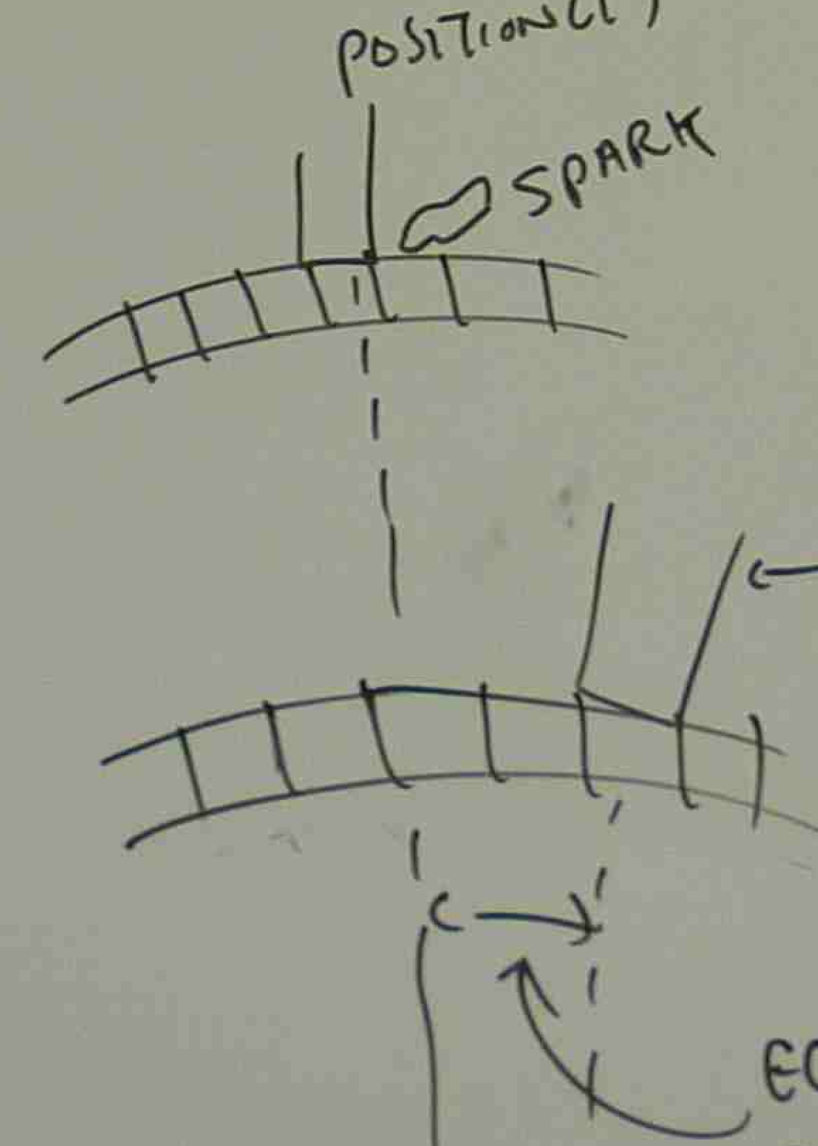


METHODS TO REDUCE ARMATURE REACTION

(1) INTER POLE



(2) SHIFT THE BRUSH



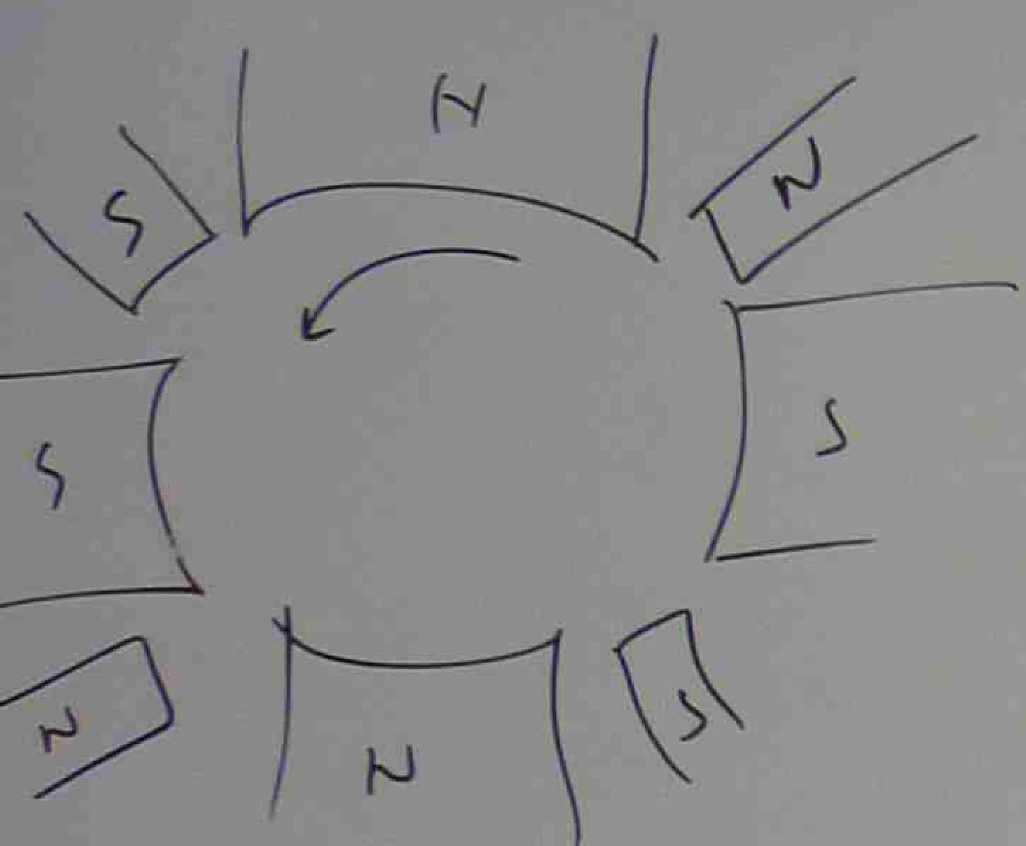
ELECTRICAL DEGREE DIFFERENCE BETWEEN ORIGINAL & FINAL BRUSH POSITION (β)

AT_d = DEMAGNETIZING AMP-TURNS / POLE = β

AT_c = CROSS MAGNETIZING AMP-TURNS / POLE = $\frac{Z I}{2 P}$

PB THE BRUSHES ON A
ROCKED 0.03 m
6 POLES, LAP WOUND
ARMATURE CURRENT
AND DEMAGNETIZING

...DUCE ARMATURE REACTION



...RUSH

— NO SPARKING

...ELECTRICAL DEGREE (β)
DIFFERENCE BETWEEN
ORIGINAL & FINAL BRUSH POSITION

AT_d = DEMAGNETIZING AMP — TURNS / POLE $= \dfrac{\beta \, Z \, I_a}{360 \, a}$

Z = NO. of CONDUCTORS

I_a = ARMATURE CURRENT

a = ARMATURE PARALLEL PATH

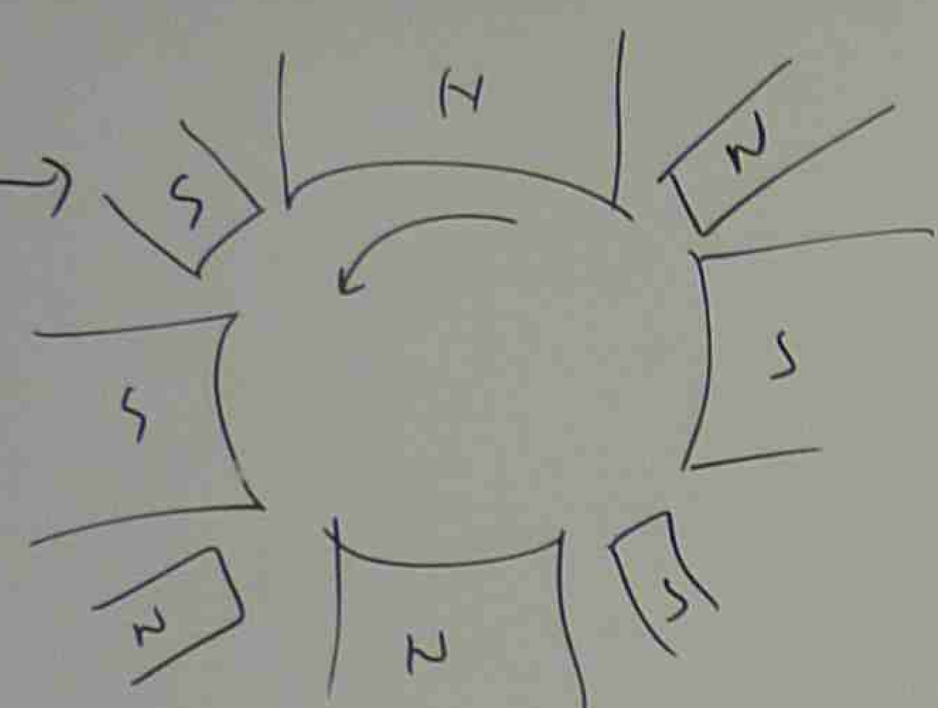
AT_c = CROSS MAGNETIZING AMP — TURNS / POLE $= \dfrac{Z \, I_a}{2P} \left(\dfrac{360 - 2P\beta}{720} \right)$

P = NO. OF POLES.

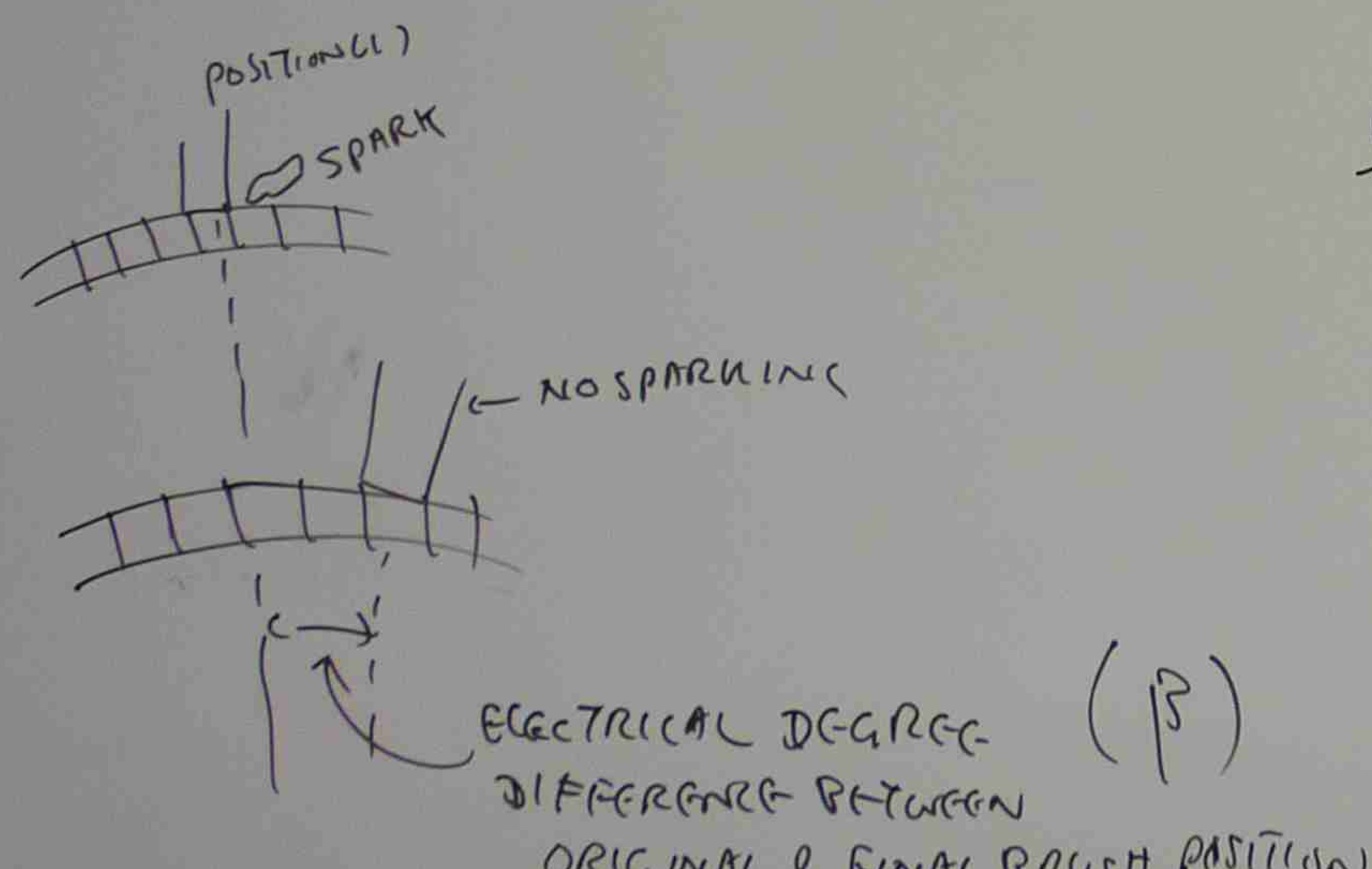
pb THE BRUSHES ON A 0.4 m DIAMETER COMMUTATOR ARE ROCKED 0.03 m CIRCUMFERENTIALLY. THE MACHINE HAS 6 POLES, LAP WOUND (SIMPLEX), 378 CONDUCTORS, 800 AMP ARMATURE CURRENT. CALCULATE CROSS MAGNETIZING AND DEMAGNETIZING AMP-TURNS / POLE.

METHODS TO REDUCE ARMATURE REACTION

(1) INTER POLE



(2) SHIFT THE BRUSH



$$AT_d = \text{DEMAGNETIZING Amp-Turns/Pole} = \frac{\beta Z I_a}{360\, a}$$

Z = NO. OF CONDUCTORS

I_a = ARMATURE CURRENT

a = ARMATURE PARALLEL PATH

β = SHIFTING OF BRUSH ANGLE

$$AT_c = \text{CROSS MAGNETIZING Amp-Turns/Pole} = \frac{Z I_a}{2P}\left(\frac{360 - 2P\beta}{720}\right)$$

P = NO. OF POLES.

Pb THE BRUSHES ON A 0.4 m DIAMETER COMMUTATOR ARE ROCKED 0.03 m CIRCUMFERENTIALLY. THE MACHINE HAS 6 POLES, LAP WOUND (SIMPLEX), 378 CONDUCTORS, 800 AMP ARMATURE CURRENT. CALCULATE CROSS MAGNETIZING AND DEMAGNETIZING AMP-TURNS/POLE. (SIMPLEX LAP)

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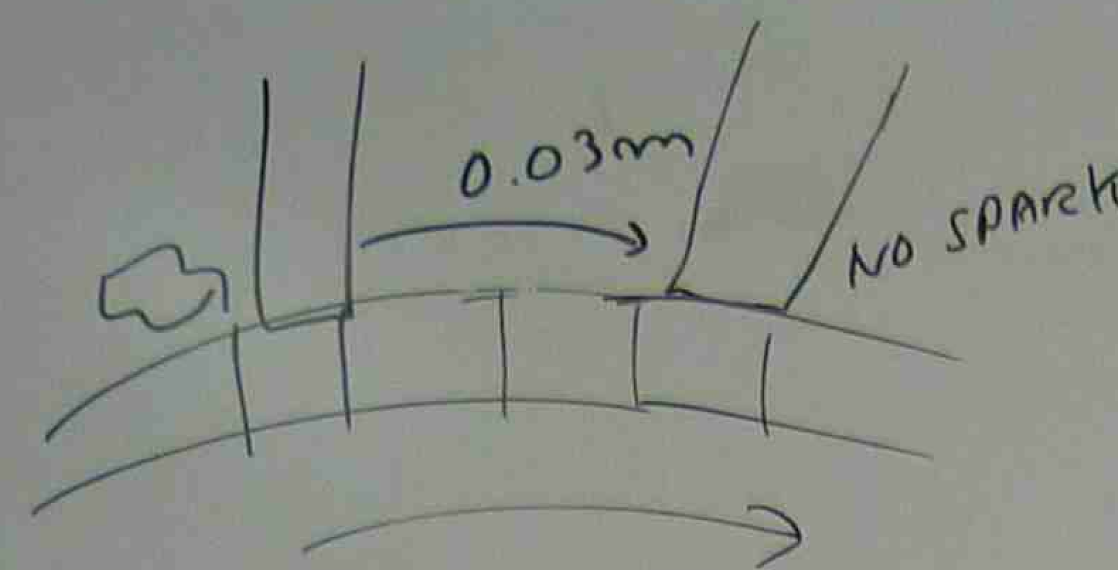


$$\beta = \frac{\text{SHIFTING CIRCUMFERENTIAL DISTANCE}}{\pi \times \text{DIAMETER}} \times 360$$

$$= \frac{0.03}{3.1416 \times 0.4} \times 360 = 8.6$$

$$\text{DEMAGNETIZING } (AT_d) = \frac{\beta Z I_a}{360\, a} = \frac{8.6 \times 378 \times 800}{360 \times 6}$$

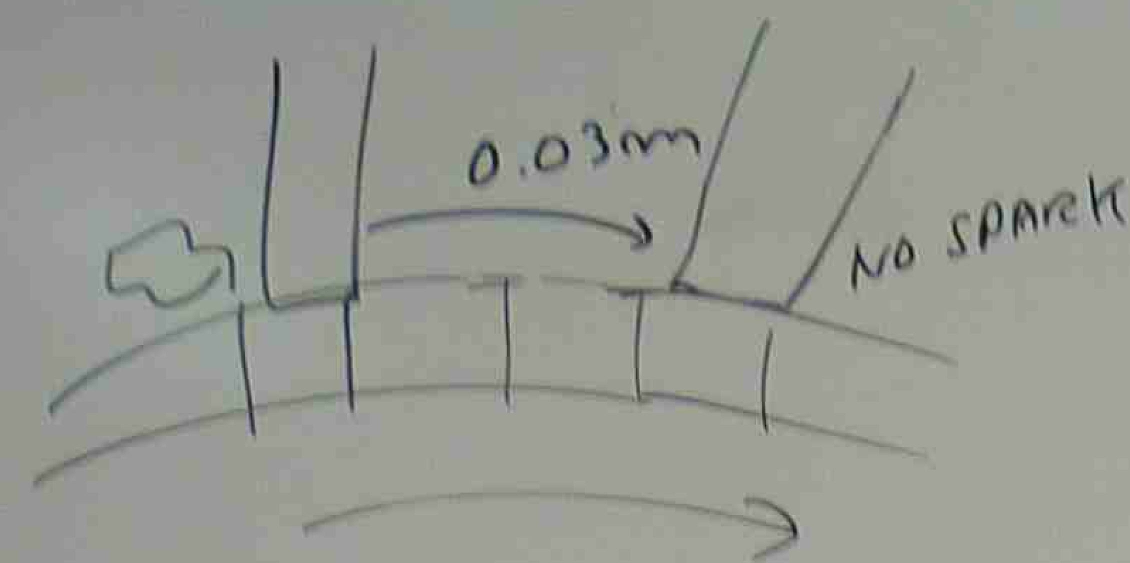
$$\left(\begin{aligned} a &= m \times P \\ &= 1 \times 6 = 6 \end{aligned} \right)$$

$$= 1210 \text{ AT/POLE}.$$

$$\text{CROSS MAGNETIZING } (AT_c) = \frac{Z I_a}{2P} \left(\frac{360 - 2P\beta}{720} \right)$$

$$= \frac{378 \times 800}{2 \times 6} \left(\frac{360 - 2 \times 6 \times 8.6}{720} \right)$$

$$= 3000 \text{ AT/POLE}$$



$$\beta = \frac{\text{SHIFTING CIRCUMFERENTIAL DISTANCE}}{\pi \times \text{DIAMETER}} \times 360$$

$$= \frac{0.03}{3.1416 \times 0.4} \times 360 = 8.6$$

$$\text{DEMAGNETIZING } (AT_d) = \frac{\beta Z I_a}{360\, a} = \frac{8.6 \times 378 \times 800}{360 \times 6}$$

$$\left(\begin{aligned} a &= m \times P \\ &= 1 \times 6 = 6 \end{aligned} \right) \qquad = 1210 \text{ AT/POLE.}$$

$$\text{CROSS MAGNETIZING } (AT_c) = \frac{Z I_a}{2P} \left(\frac{360 - 2P\beta}{720} \right)$$

$$= \frac{378 \times 800}{2 \times 6} \left(\frac{360 - 2 \times 6 \times 8.6}{720} \right)$$

$$= 3000 \text{ AT/POLE}$$

Simplex

Duplex

4 poles
series

4 poles
series/para

1

360

$$\frac{.6 \times 378 \times 800}{360 \times 6}$$

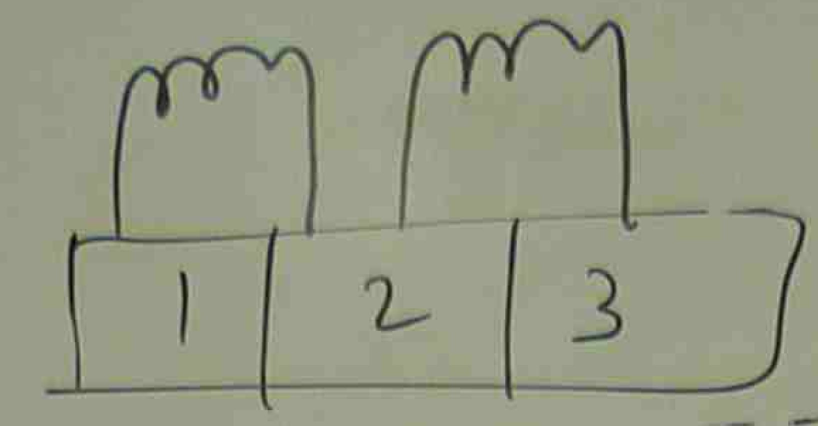
210 AT / pole.

$$\left(\frac{360 - 2p\beta}{720}\right)$$

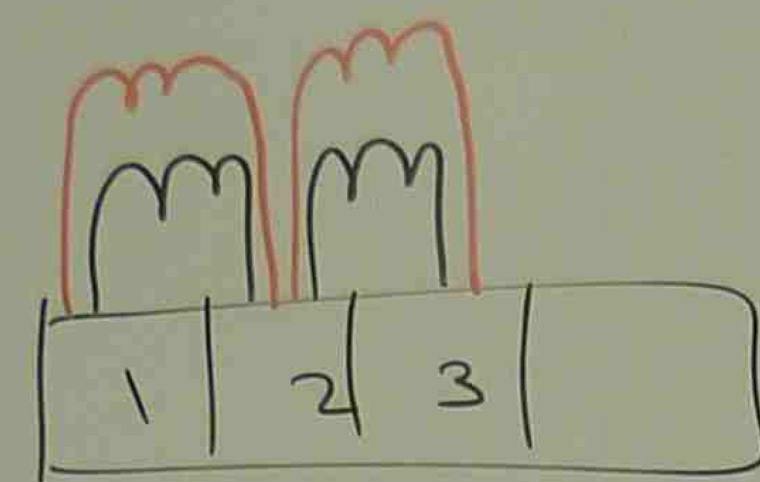
$$\left(\frac{360 - 2 \times 6 \times 8.6}{720}\right)$$

/pole

Simplex



Duplex

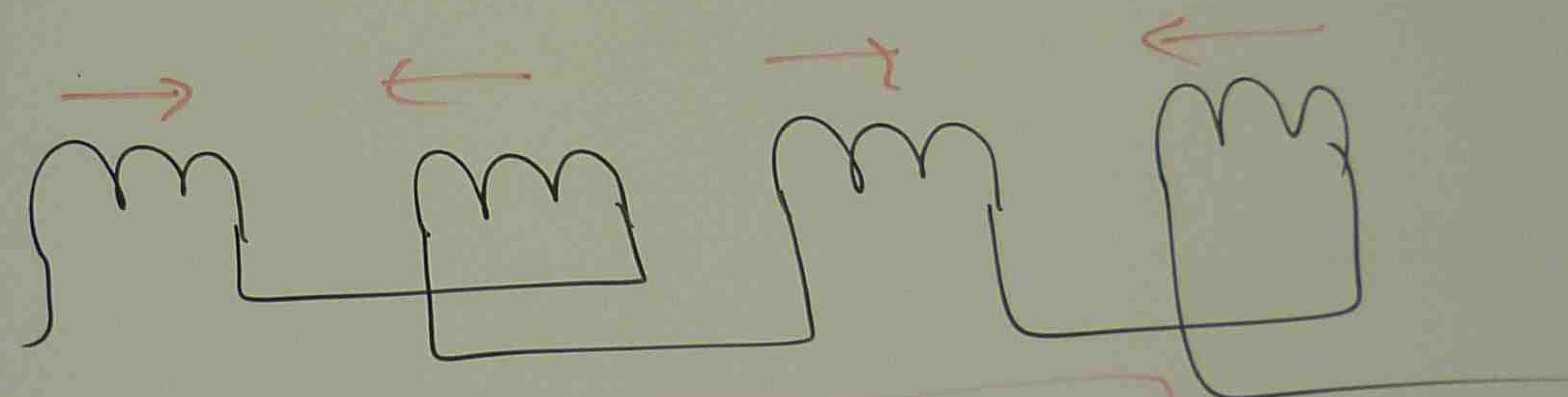


$a = m \times P$ Lap

$a = 2 \times m$ wave

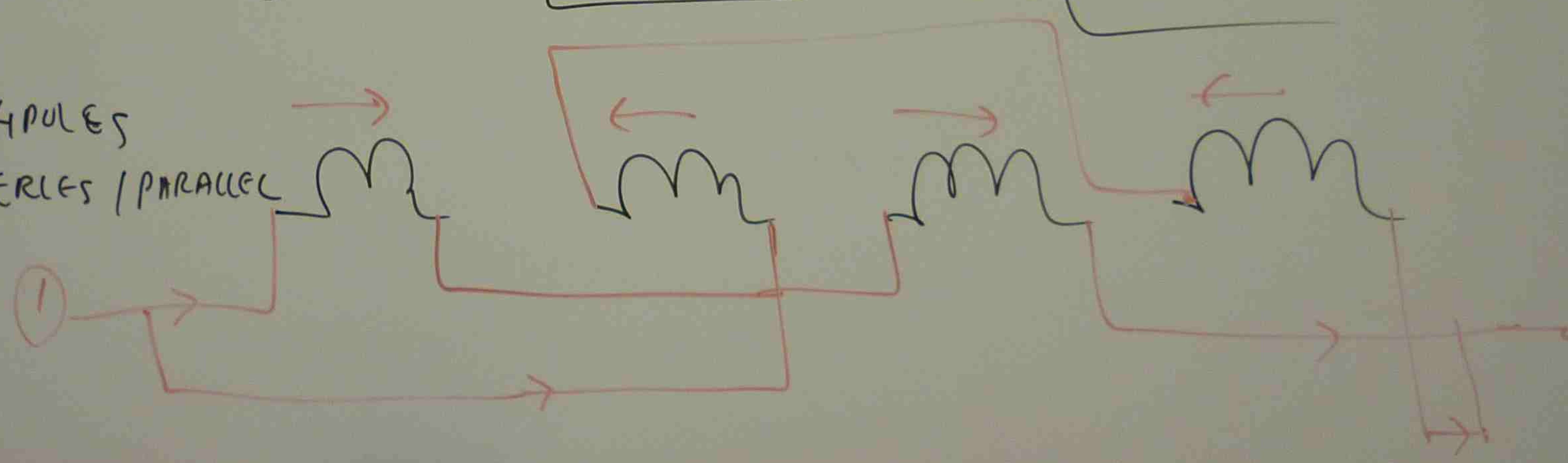
4 poles

Series



4 poles

Series / Parallel



Volt

The vol

N =

t =

Z =

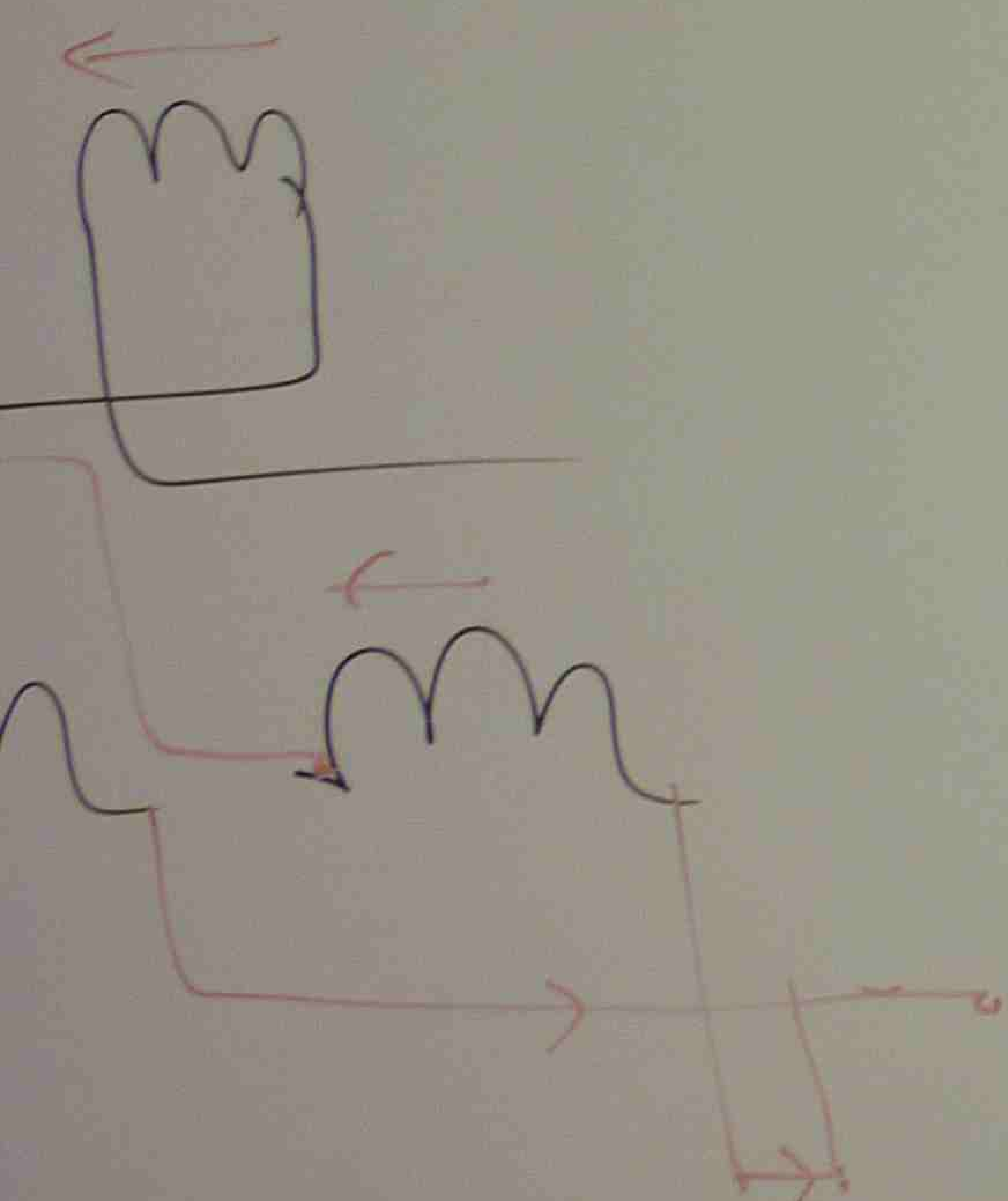
ϕ_c =

- The
In
Sho

- To
The
Fo

$n \times P$ LAP

$2 \times m$ WAVE



VOLTAGE OF SELF INDUCTION

THE VOLTAGE OF SELF INDUCTION = $\dfrac{N \, Z \, \phi_c}{t}$ VOLT

N = TURN / COIL SHORT CIRCUITED DURING COMMUTATION

t = TIME DURING WHICH CURRENT IS REVERSING

Z = NO. OF ARMATURE CONDUCTORS

ϕ_c = FLUX

- THE BRUSH CONTACT RESISTANCE PLAYS A VERY IMPORTANT PART IN LIMITING THE CIRCULATING CURRENT WHEN THE BRUSH SHORT CIRCUITS THE COIL.

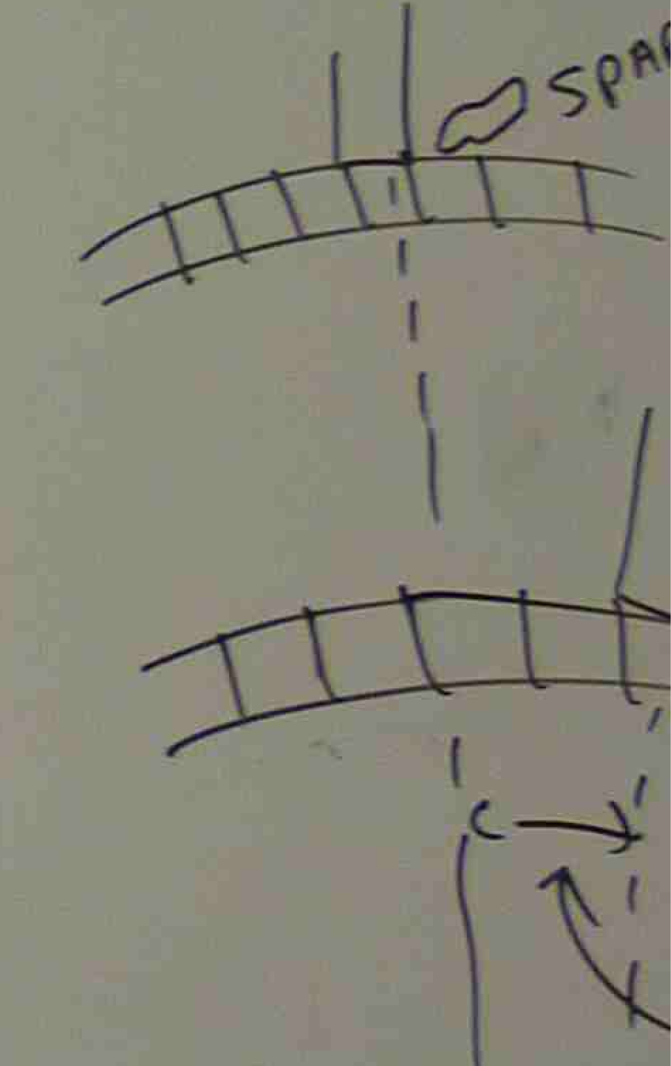
- TO IMPROVE THE COMMUTATION, IT NEEDS TO MOVE A LITTLE THE BRUSH IN FORWARD DIRECTION OF MACHINE ROTATION FOR GENERATOR AND BACKWARD FOR MOTOR.

METHODS TO R

(1) INTER POLE

(2) SHIFT THE

POSITION



...T

...TATION

...SING

...Y IMPORTANT PART

...HEN THE BRUSH

MOVE A LITTLE

...ACHING ROTATION

...R.

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STAGE (4)

G044	7762AC

G044_7762AC1

G044_7762AC2

G044_Tutorial

G043 + G045

7762AF

G043_G045_7762AF Notes 1

G043_G045_7762AF Notes 2

G015_ G046_ G040_ G043_ G045_G042 Tutorial

7762AA
AC
AG

7762AE

7762AD

7762AF

7762AH
4269T

GENERATED

$E_g = \phi$ ...

$E_g =$ GEN...

Z. NO...

N = RP...

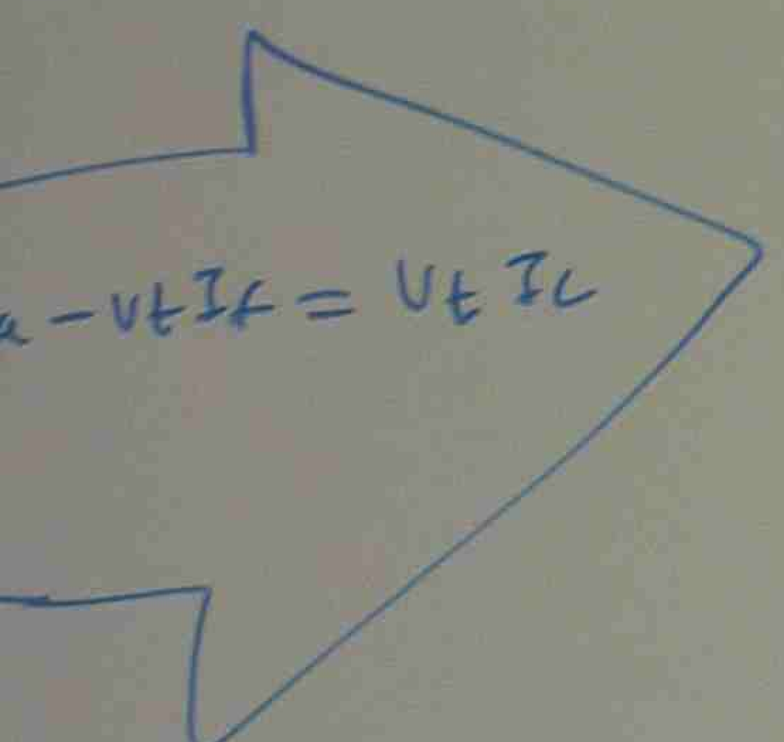
P = NO. ...

a = NO...

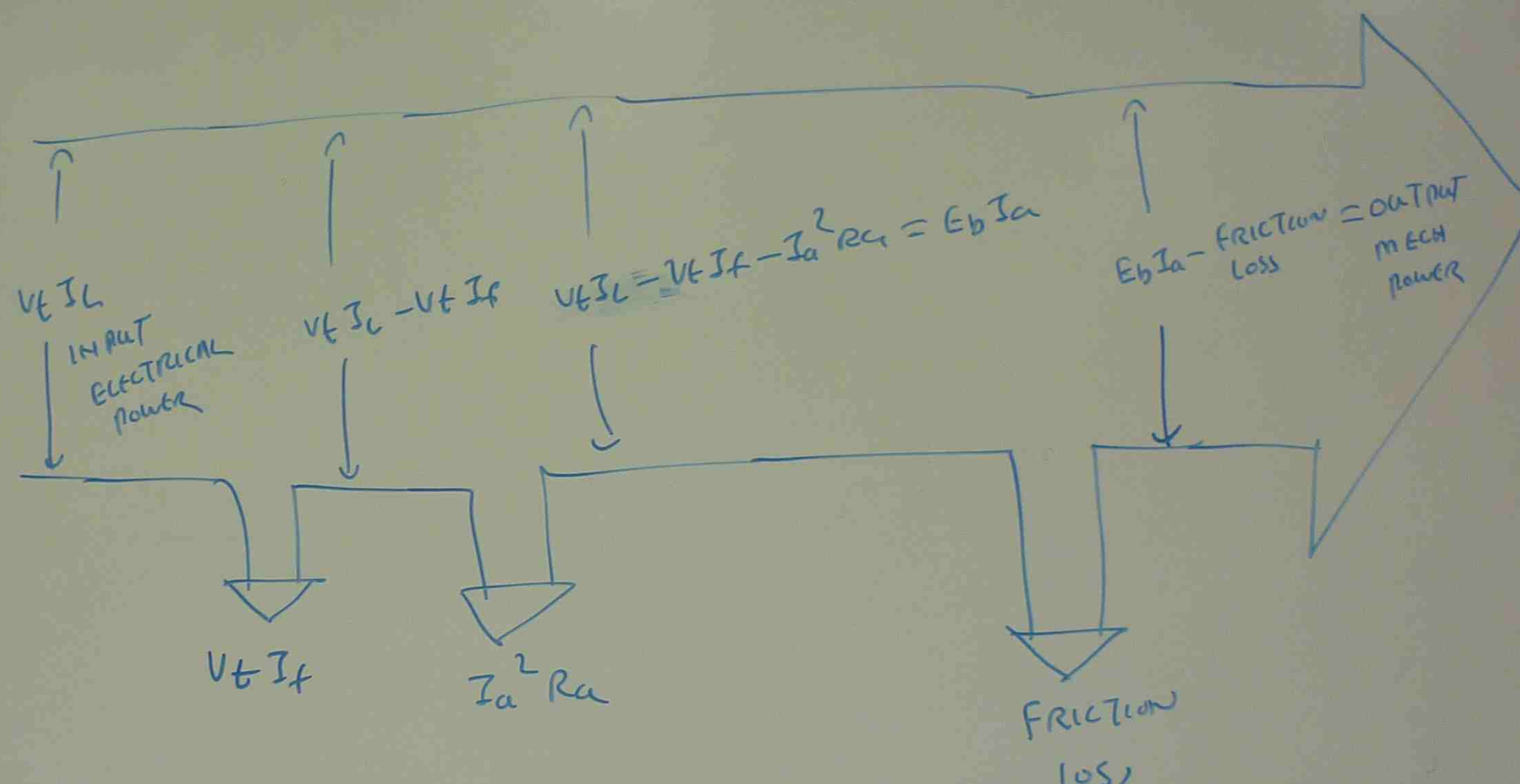
$E_b =$ ...

Eg

R



POWER FLOW DIAGRAM IN DC MOTOR



$$\% = \frac{\text{OUTPUT}}{\text{INPUT}} \times 100 = \left(1 - \frac{\text{Power loss}}{P_{out} + P_{loss}}\right) \times 100$$

pb THE

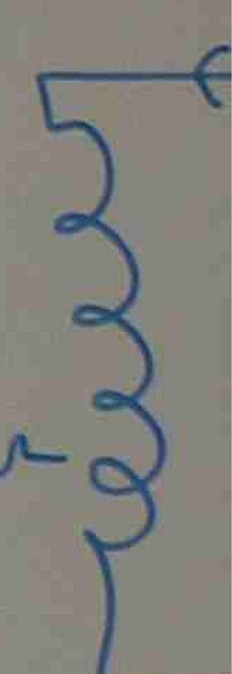
MOTOR

IF THE

DETER

(a)

(b)



(OUT

I_{sh}

LOSSES AND EFFICIENCY IN DC MACHINE

CONSTANT LOSS

ROTATIONAL LOSSES

- → HEAT PRODUCED BY BEARING
- → HEAT PRODUCED BY ARMATURE CONDUCTOR

BEARING FRICTION, WIND FRICTION, BRUSH FRICTION,

EDDY CURRENT & HYSTERESIS LOSS, WINDAGE LOSS,

AMOUNT OF LOSS DEPENDS ON

- MAGNETIC IRON
- FREQUENCY OF SUPPLY
- FLUX DENSITY
- MASS OF IRON

HYSTERESIS LOSS

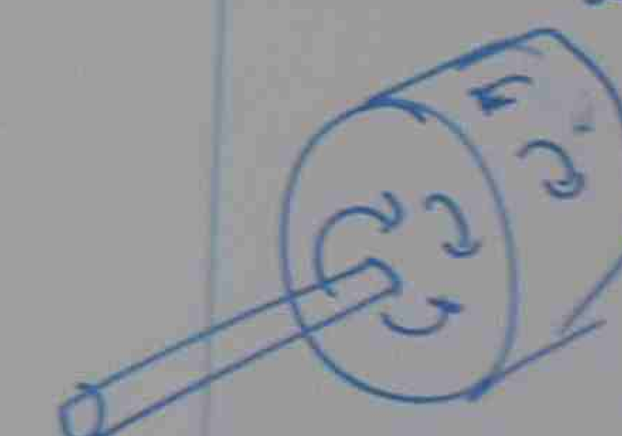
K_h = CONST

f = FREQ

B = MAX

m = MA

EDDY CURRENT LOSS



K_e = CONSTA

& DI

f = FREQU

t = THIC

B = MAX

V = VOL

MACHINE

...ED BY BEARING

...ER BY ARMATURE

BRUSH FRICTION,

WINDAGE LOSS,

...RON

of SUPPLY

...TY

IRON

HYSTERESIS LOSS $\boxed{P_h = K_h f B^{1.6} m}$ WATT

K_h = CONSTANT DEPENDING ON MATERIALS & UNIT USED

f = FREQUENCY of SUPPLY

B = MAXIMUM FLUX DENSITY of SUPPLY (T)

m = MASS OF CORE (Kg)

EDDY CURRENT LOSS

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

K_e = CONSTANT DEPENDS ON RESISTIVITY OF IRON & DIMENSION

f = FREQUENCY (HZ)

t = THICKNESS of LAMINATION (m)

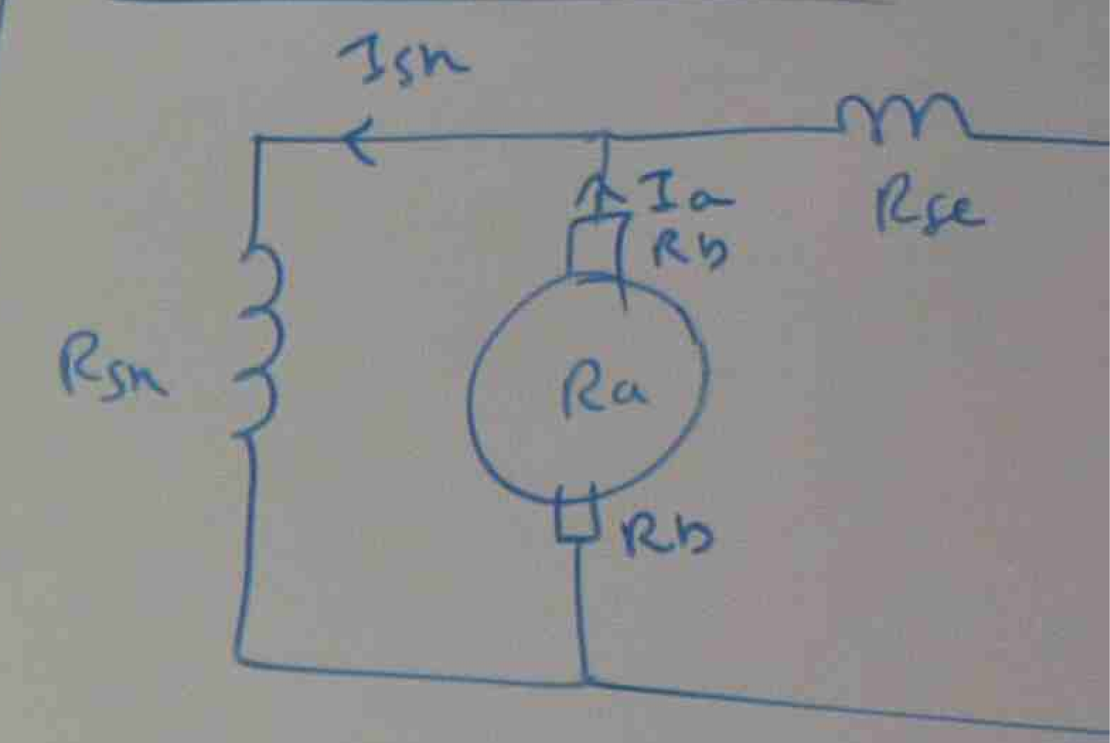
B = MAXIMUM FLUX DENSITY IN CORE (T)

V = VOLUME of IRON CORE (m^3)

COPPER LOSS

DC COMPOUND GENERATOR

SHORT SHUNT COMPOUND

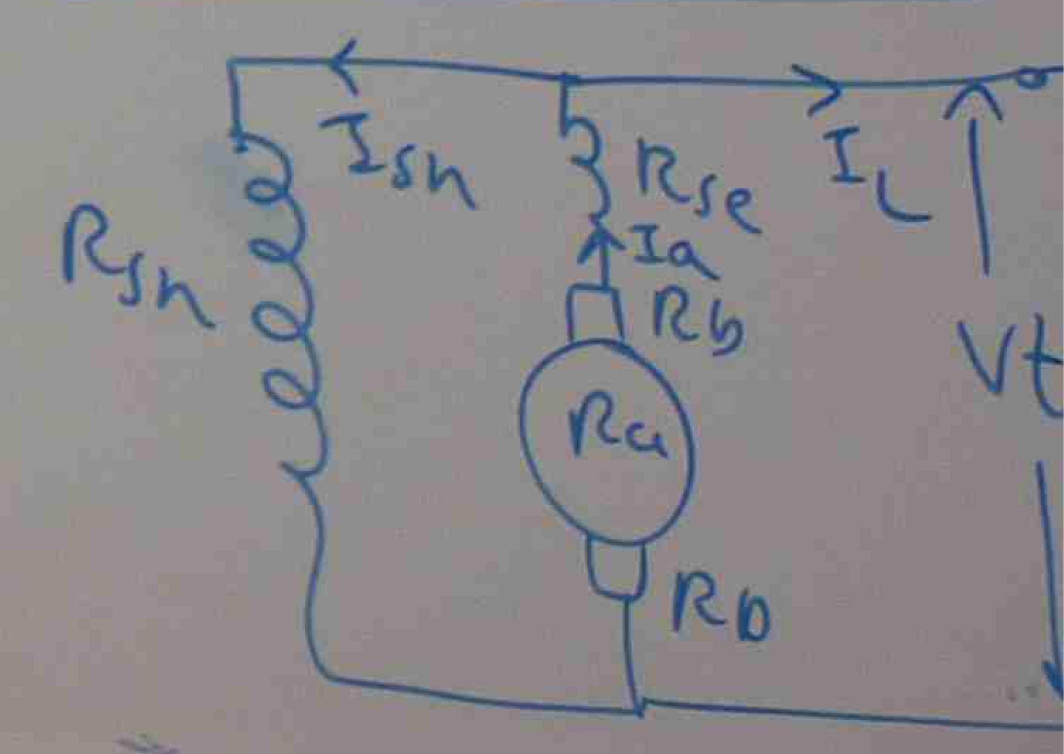


$I_a = I_{sh} + I_L$

$$I_{sh} = \frac{V_t + I_L \times R_{se}}{R_{sh}}$$

TOTAL COPPER LOSS = $I_a^2 R$...

LONG SHUNT COMPOUND



n WATT

IALS & UNIT USED

SUPPLY (T)

$B^2 V$ WATT

E-SISTIVITY OF IRON

ATION (m)

Y IN CORE (T)

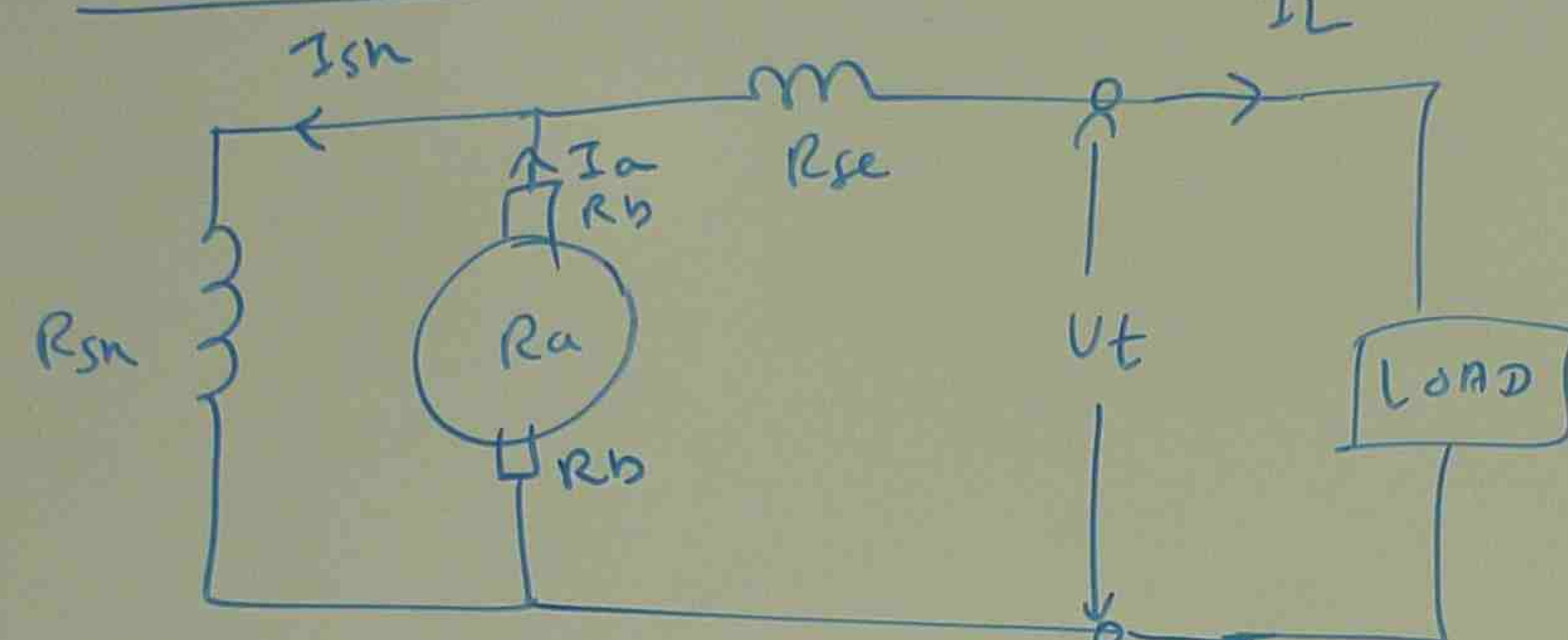
(m^3)

COPPER LOSS

VARIABLE LOSS

DC COMPOUND GENERATOR

SHORT SHUNT COMPOUND

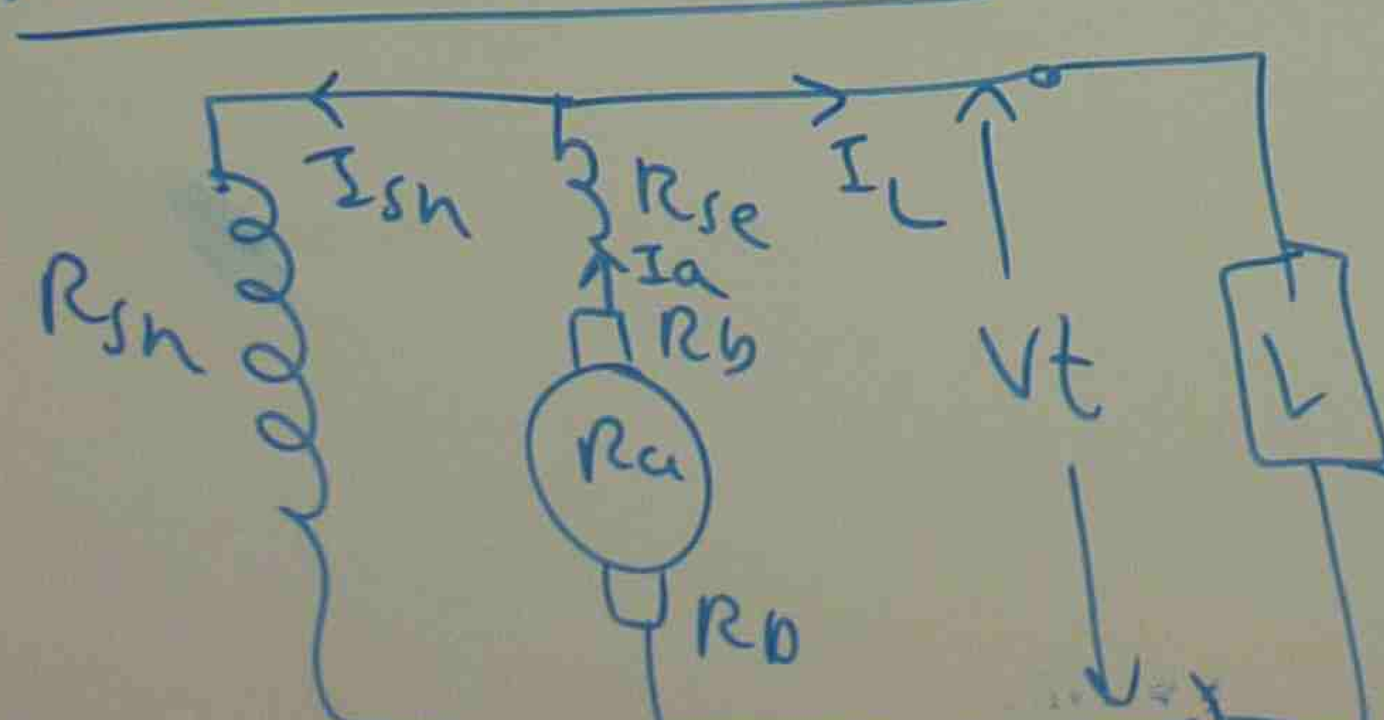


$$I_a = I_{sh} + I_L$$

$$I_{sh} = \frac{V_t + I_L \times R_{se}}{R_{sh}}$$

TOTAL COPPER LOSS = $I_a^2 R_a + 2 I_a^2 R_b + I_{sh}^2 R_{sh} + I_L^2 R_{se}$

LONG SHUNT COMPOUND



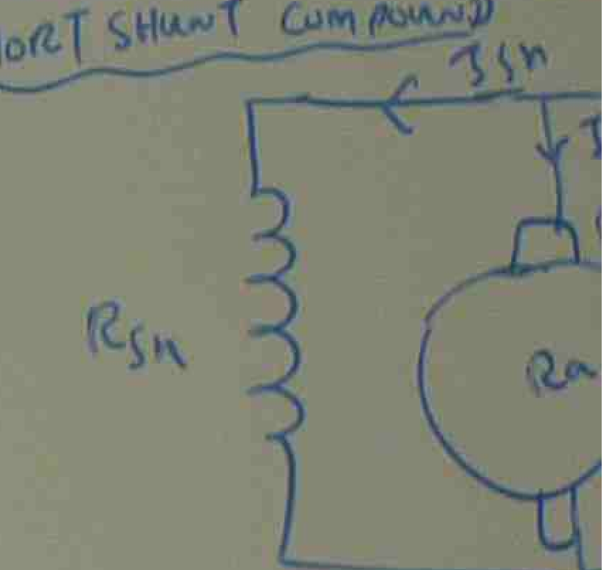
$$I_a = I_L + I_{sh}$$

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

TOTAL COPPER LOSS

DC COMPOUND MO

SHORT SHUNT COMPOUND



$I_{sh} =$ Vt

$I_a =$ I

TOTAL COPPER L

TOTAL LO

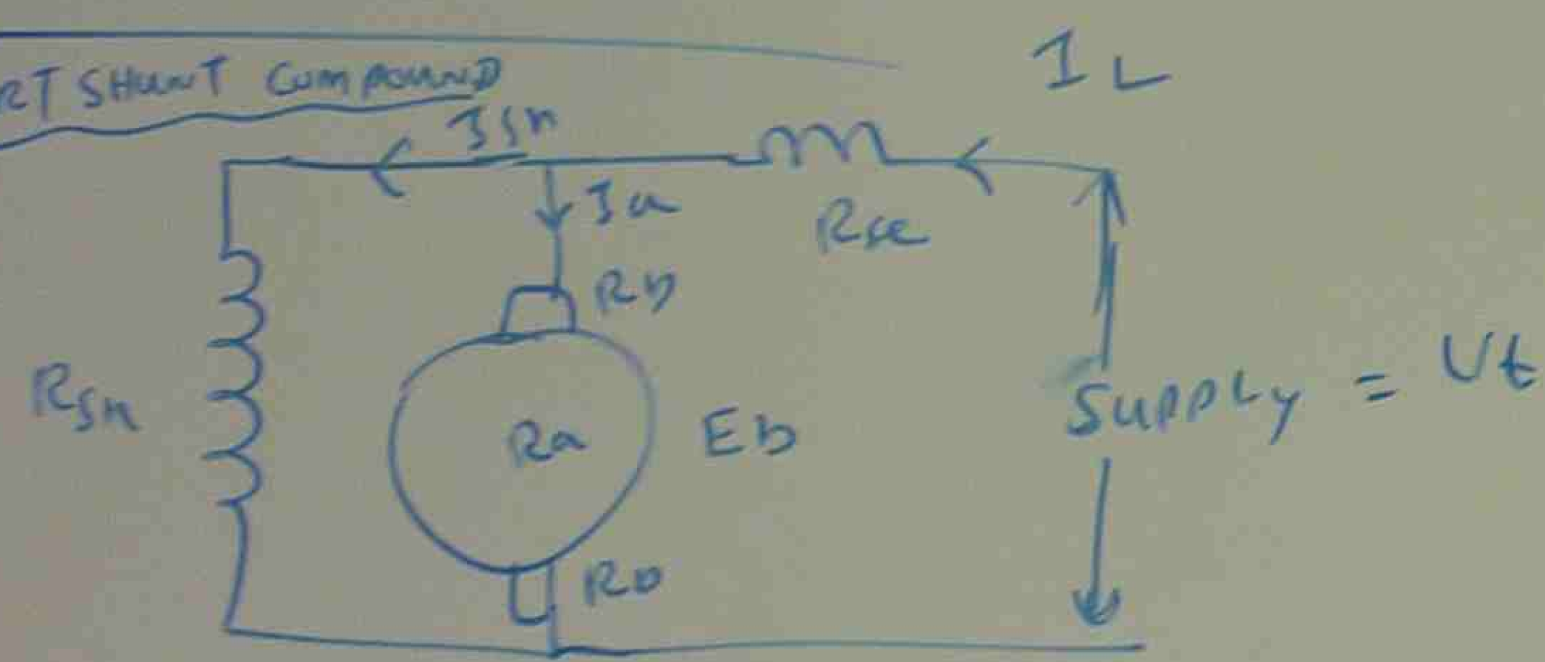
INPUT PO

INPUT E

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

DC COMPOUND MOTOR

SHORT SHUNT COMPOUND

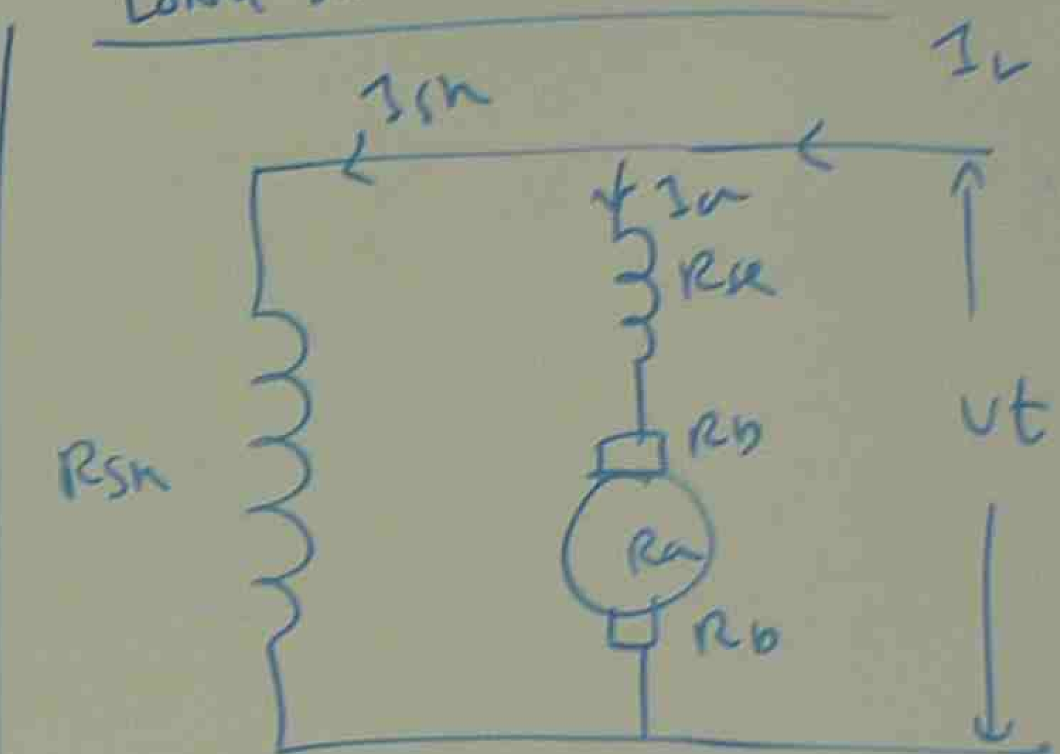


$$I_{sh} = \frac{V_t - I_L R_{se}}{R_{sh}}$$

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

TOTAL COPPER LOSS = $I_a^2 R_a + 2 I_a^2 R_b + I_{sh}^2 R_{sh} + I_L^2 R_{se}$

LONG SHUNT COMPOUND



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

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

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

TOTAL LOSSES = IRON LOSS + WINDAGE & FRICTION LOSS + TOTAL COPPER LOSS

INPUT POWER (MECHANICAL POWER) GENERATOR = OUTPUT ELECTRICAL POWER + TOTAL LOSSES

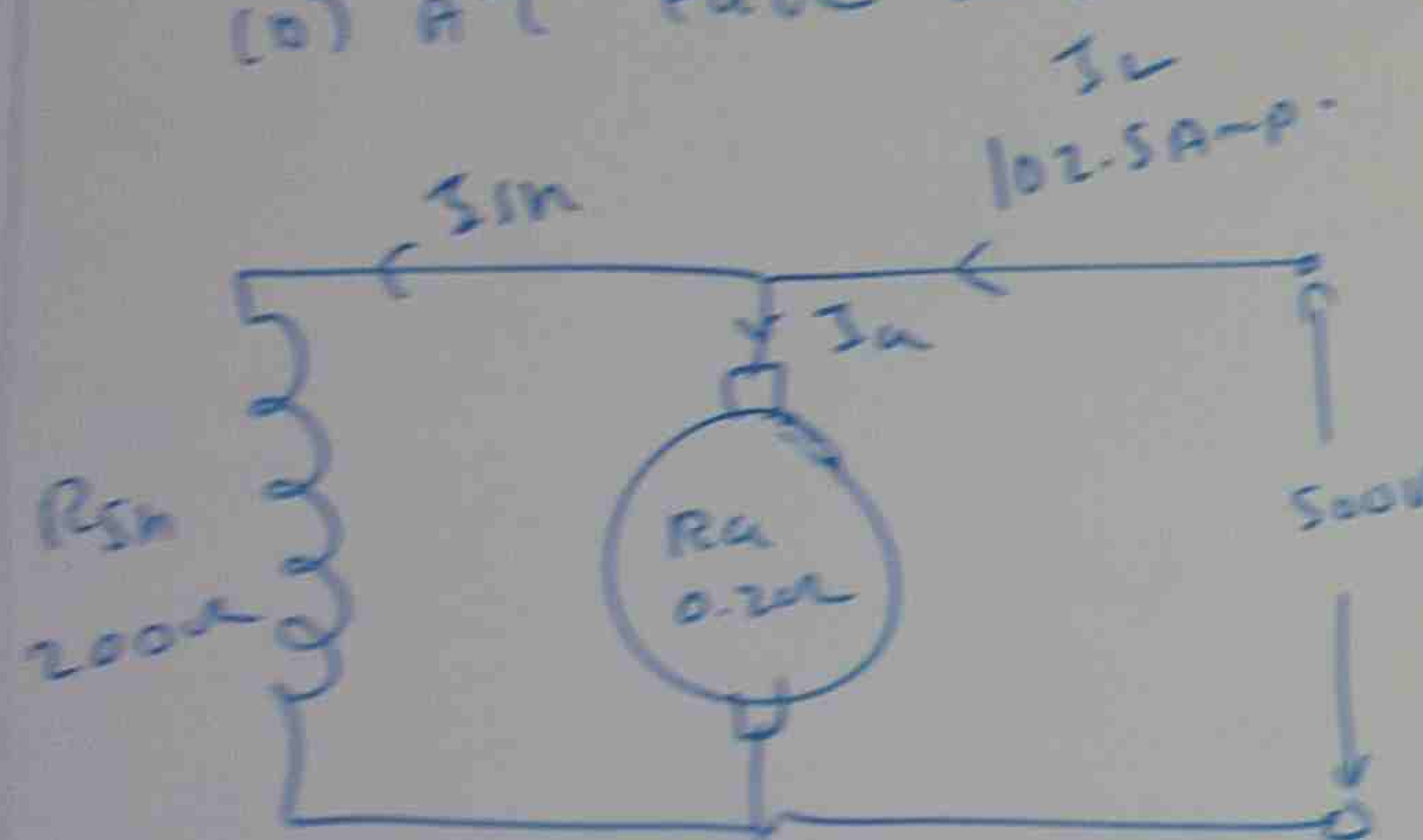
INPUT ELECTRICAL POWER (MOTOR) = OUTPUT MECHANICAL POWER + TOTAL LOSSES.

Pb/ THE WINDING RESISTANCE OF A 500V, 60KW DC SHUNT MOTOR ARE $R_a = 0.2\Omega$, $R_f = 200\Omega$

IF THE ROTATIONAL LOSSES CAN BE TAKEN AS 1.4KW, DETERMINE THE EFFICIENCY OF THE MACHINE.

(a) WHEN THE LINE CURRENT IS 102.5 Amp

(b) AT FULL LOAD



(OUT PUT POWER = 60KW FULL LOAD.)

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{500}{200} = 2.5\text{Amp}$$

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

$$= 102.5 - 2.5$$

$$= 100 \text{ Amp.}$$

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

$$= 100^2 \times 0.2 + 2.5^2 \times 200$$

$$= 3250 \text{ W}$$

TOTAL LOSS = COPPER LOSS + IRON/FRICTION LOSS

$$= 3250 + 1400$$

$$= 4650 \text{ W}$$

$$\text{INPUT POWER} = V_t I_L = 500 \times 102.5 =$$

$$\text{OUT PUT POWER} = \text{INPUT} - \text{TOTAL LOSS}$$

$$= 500 \times 102.5 - 4650$$

$$\text{Efficiency} = \frac{\text{OUT PUT POWER}}{\text{INPUT POWER}} \times 100$$

$$= \frac{500 \times 102.5 - 4650}{500 \times 102.5} \times 100$$

$$= 90.93\%.$$

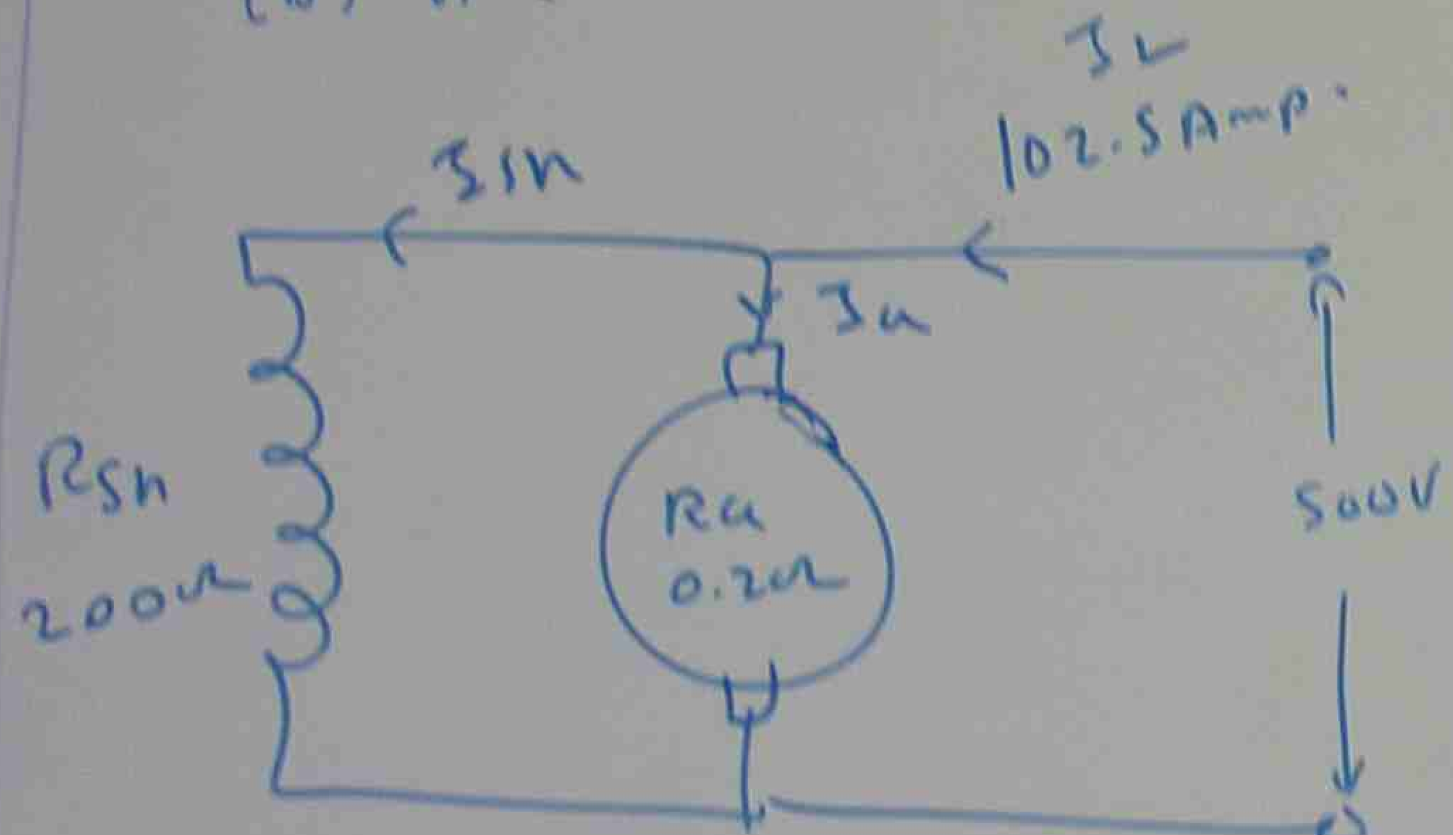
Rsh =

pb THE WINDING RESISTANCE OF A 500V, 60KW DC SHUNT MOTOR ARE $R_a = 0.2\Omega$, $R_f = 200\Omega$

IF THE ROTATIONAL LOSSES CAN BE TAKEN AS 1.4KW, DETERMINE THE EFFICIENCY OF THE MACHINE.

(a) WHEN THE LINE CURRENT IS 102.5 Amp

(b) AT FULL LOAD



(OUT PUT POWER = 60KW FULL LOAD.)

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{500}{200} = 2.5\text{Amp}$$

$$I_a = I_L - I_{sh}$$
$$= 102.5 - 2.5$$
$$= 100 \text{ Amp.}$$

$$\text{TOTAL COPPER LOSS} = I_a^2 R_a + I_{sh}^2 R_{sh}$$
$$= 100^2 \times 0.2 + 2.5^2 \times 200$$
$$= 3250W$$

TOTAL LOSS = COPPER LOSS + IRON/FRICTION LOSS

$$= 3250 + 1400$$
$$= 4650W$$

$$\text{INPUT POWER} = V_t I_L = 500 \times 102.5 =$$

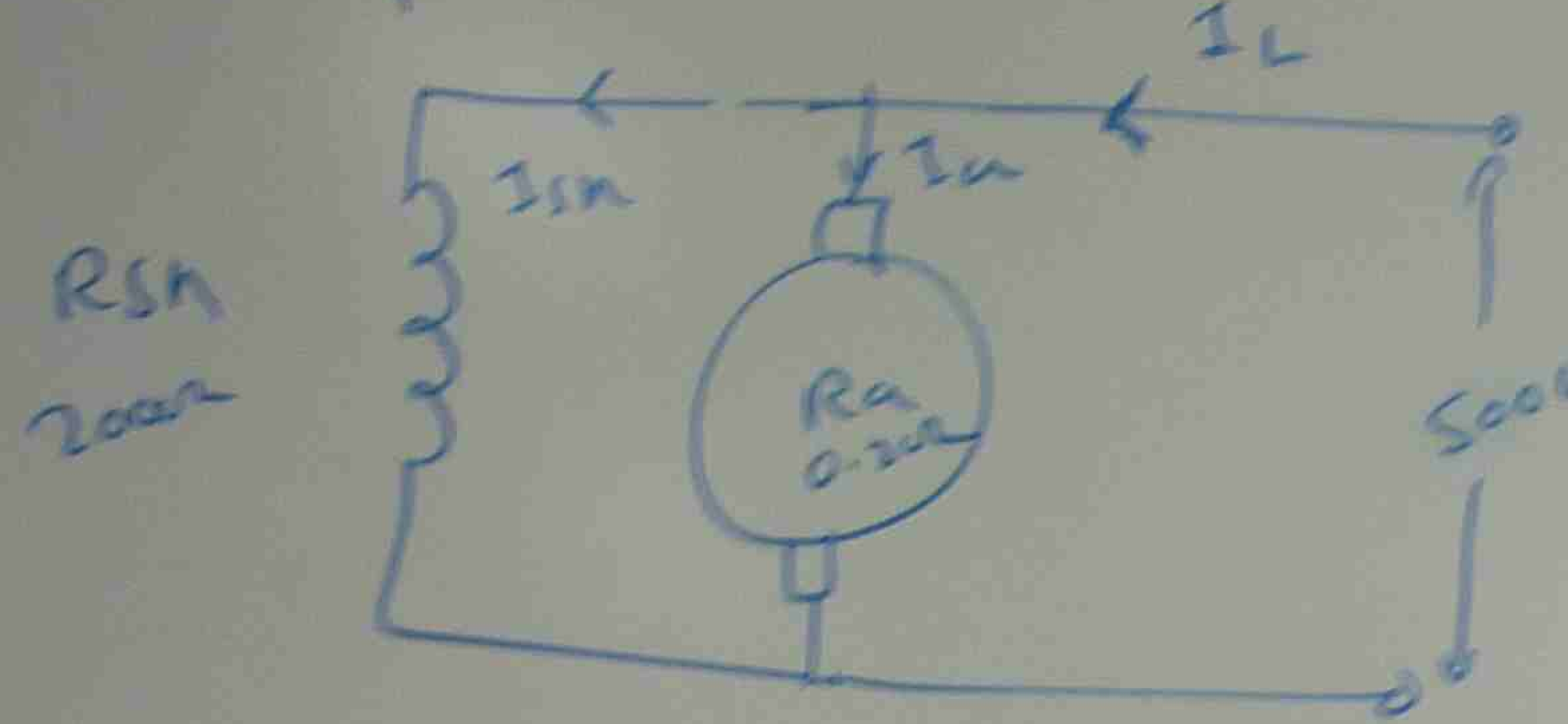
$$\text{OUT PUT POWER} = \text{INPUT} - \text{TOTAL LOSS}$$
$$= 500 \times 102.5 - 4650$$

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

$$= \frac{500 \times 102.5 - 4650}{500 \times 102.5} \times 100$$

$$= 90.93\%.$$

FULL LOAD



POWER OUT PUT (P_{OUT}) = 60,000 WATT

$$P_{OUT} = 60,000 \text{ W}$$

P_{OUT} + IRON LOSS + FRICTION LOSS + COPPER LOSS = TOTAL POWER INPUT

$$60,000 + 1400 + I_{sh}^2 R_{sh} + I_a^2 R_a = V I_L$$

$$61400 + (2.5)^2 \times 200 + (I_L + I_{sh})^2 \times 0.2 = 500 \times I_L$$

$$61400 + 6.25 \times 200 + (I_L + 2.5)^2 \times 0.2 = 500 I_L$$

$$62650 + (I_L^2 + 5I_L + 6.25) \times 0.2 = 500 I_L$$

$$(I_L + 2.5)^2$$

$$\begin{array}{r} I_L + 2.5 \\ I_L + 2.5 \\ \hline I_L^2 + 2.5 I_L \\ 2.5 I_L + (2.5)^2 \\ \hline I_L^2 + 5 I_L + 6.25 \end{array}$$

$62650 + 0.2 I_L$ ...

$0.2 I_L^2 - 4$ ...

$ax^2 + b$ ...

$x =$

$I_L =$

$I_L =$

$= 4$ ...

$I_a = I$ ...

$+(2.5)^2$

6.25

L

L

$62650 + 0.2 I_L^2 + 1 I_L + 1.25 = 500 I_L$

$0.2 I_L^2 - 499 I_L + 62651.25 = 0$

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

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

$$I_L = \frac{-(-499) \pm \sqrt{499^2 - 4 \times 0.2 \times 62651.25}}{2 \times 0.2}$$

$$\frac{499 \pm \sqrt{249001 - 50121}}{0.4}$$

$$I_L = \frac{499 \pm 445.95}{0.4}$$

$$= \frac{499 + 445.95}{0.4} \text{ (OR) } \frac{499 - 445.95}{0.4}$$

$= 2362\,A$ (OR) $132.65\,A$ ✓

IMPOSSIBLE

$I_a = I_L - I_{sh} = 132.65 - 2.5 = 130.15$ Amp.

TOTAL COPPER LOSS $= I_a^2 Ra + I_{sh}^2 Rsh$

$= (130.15)^2 \times 0.2 + (2.5)^2 \times 200$

$= 4637$ WATT.

TOTAL IRON LOSS ROTATIONAL LOSS $= 1400$ WATT

TOTAL LOSSES $= 4637 + 1400 = 6037$ WATT

INPUT POWER $=$ OUTPUT POWER $+$ TOTAL LOSSES

$= 60{,}000 + 6037$

$= 66037$ WATT

$$\text{EFFICIENCY} = \frac{\text{OUTPUT POWER}}{\text{INPUT POWER}} \times 100$$

$$= \frac{60{,}000}{66037} \times 100$$

$= 90.85\%$

esn

s)^2 x 200

37 WATT

R + TOTAL LOSSES

6037

WATT

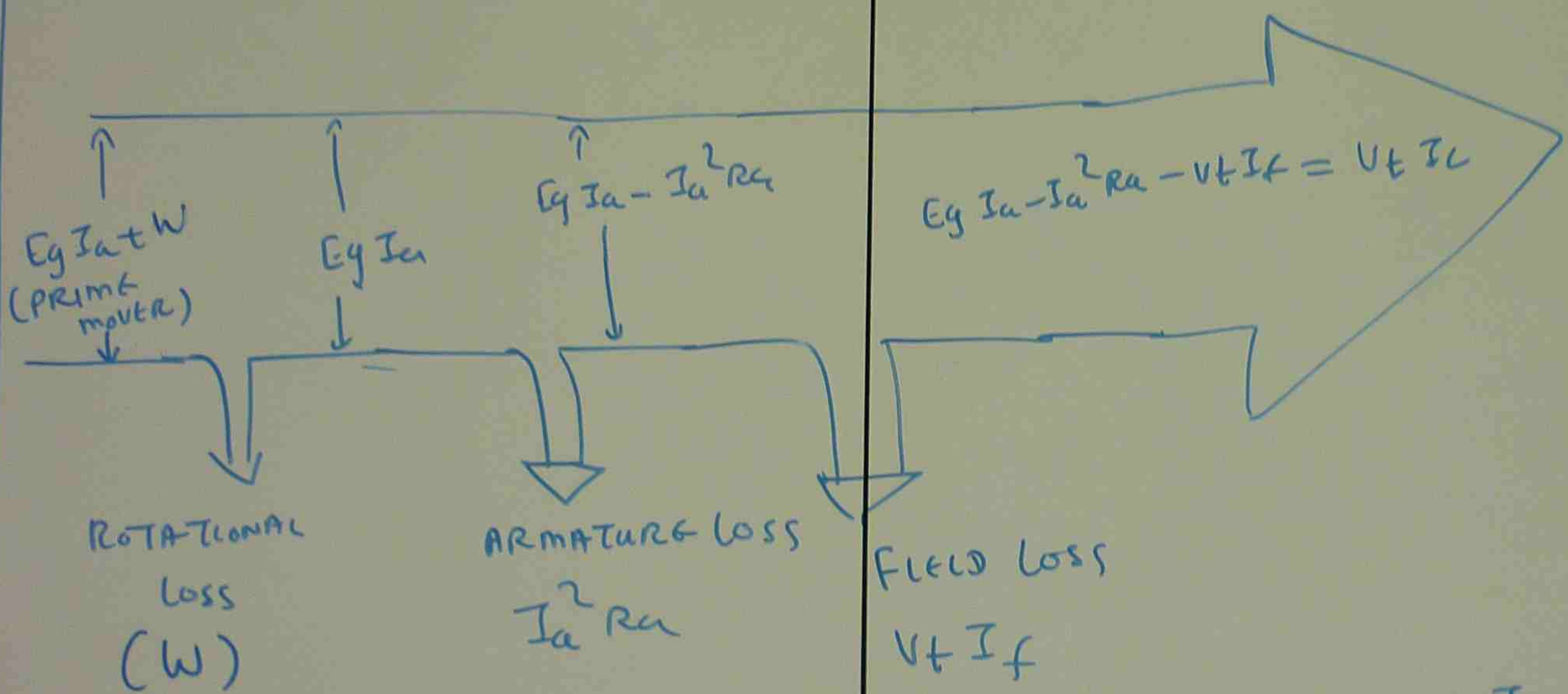
x100

00

POWER FLOW DIAGRAM IN DC GENERATOR

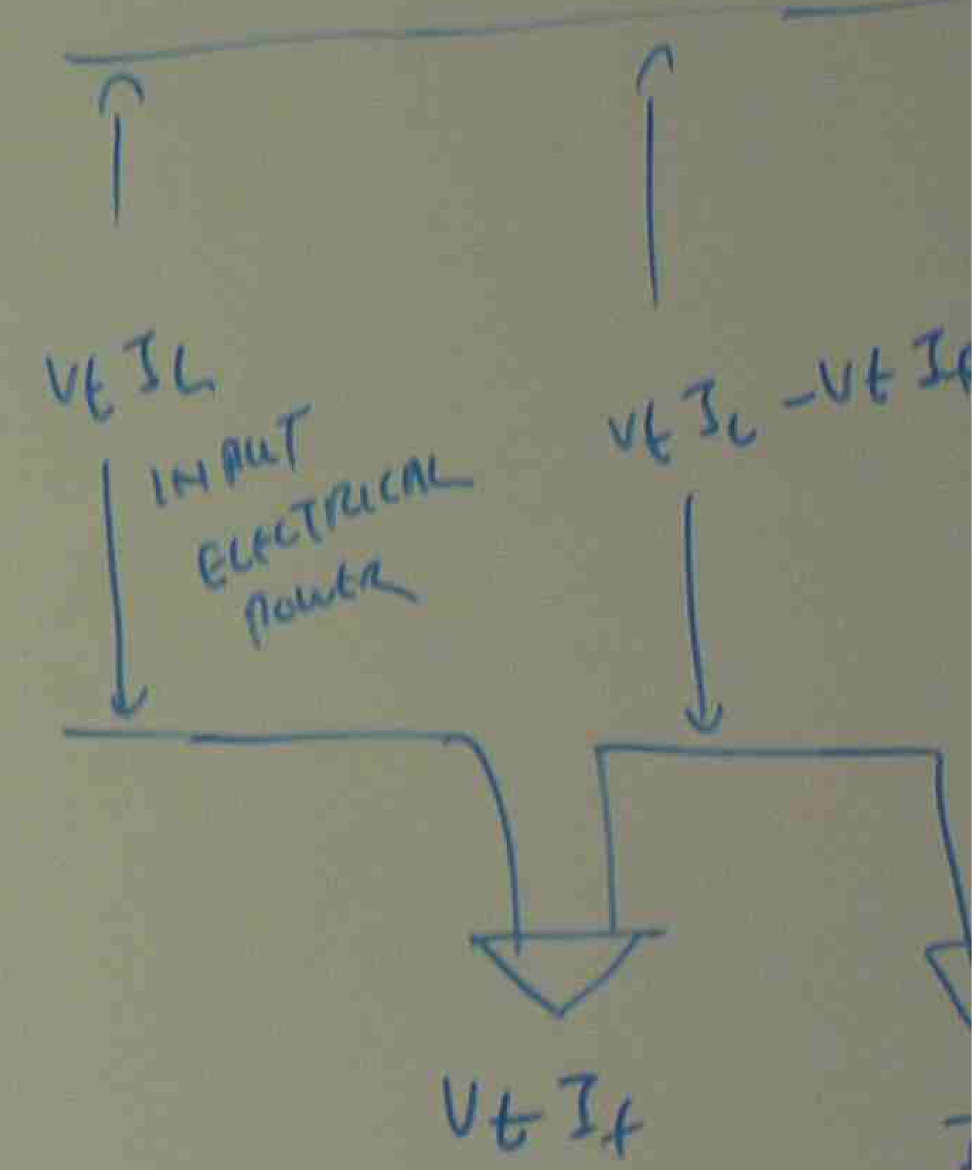
$$P_{OUT} = V_t \times I$$

$$P_{IN} = E_g I_a + \text{ROTATIONAL LOSSES}$$



$$\eta\,\% = \frac{\text{OUTPUT}}{\text{INPUT}} \times 100 = \left(1 - \frac{\text{POWER LOSS}}{P_{OUT} + P_{LOSS}}\right) \times 100$$

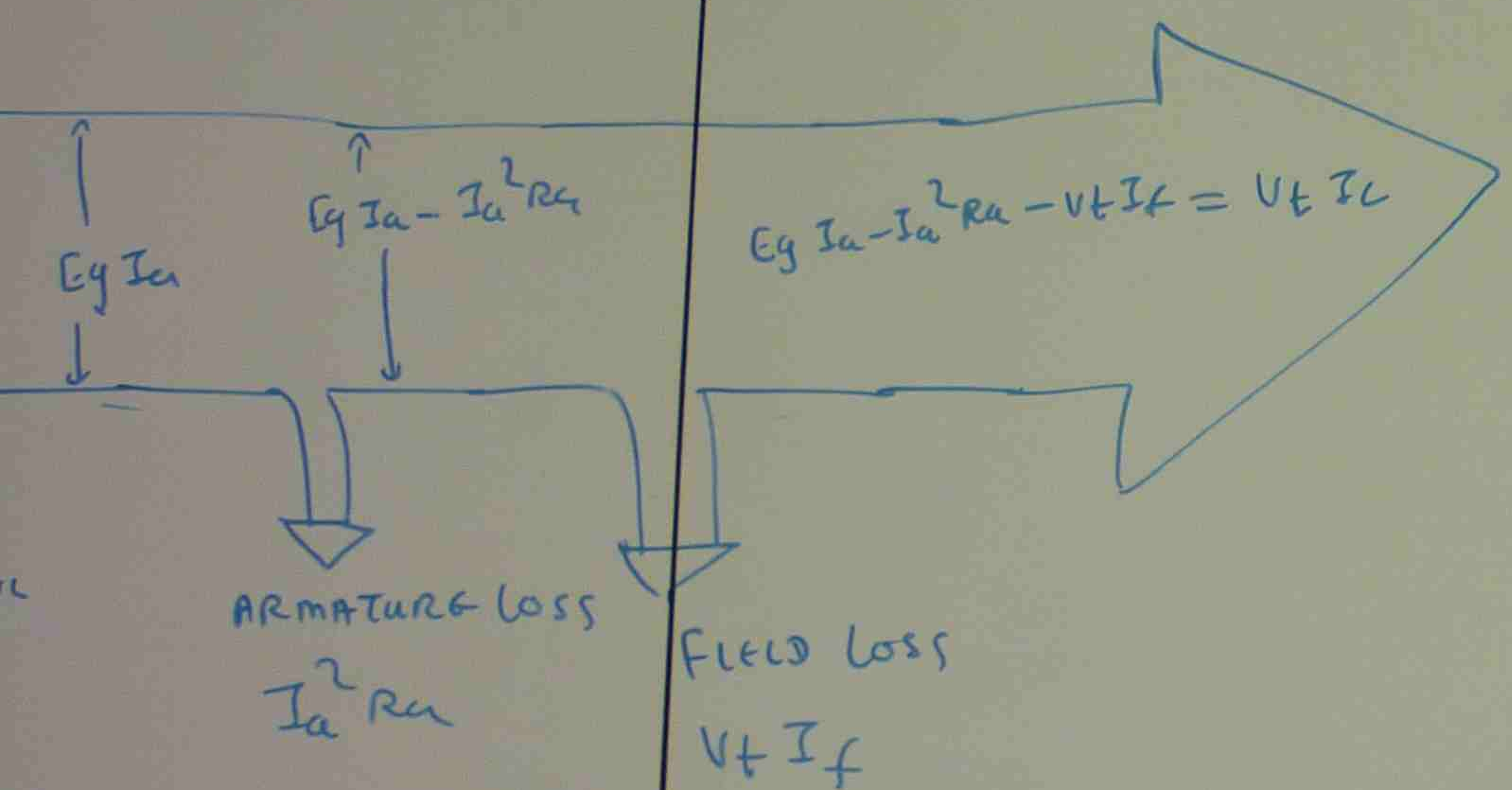
POWER FLOW DIAGRA



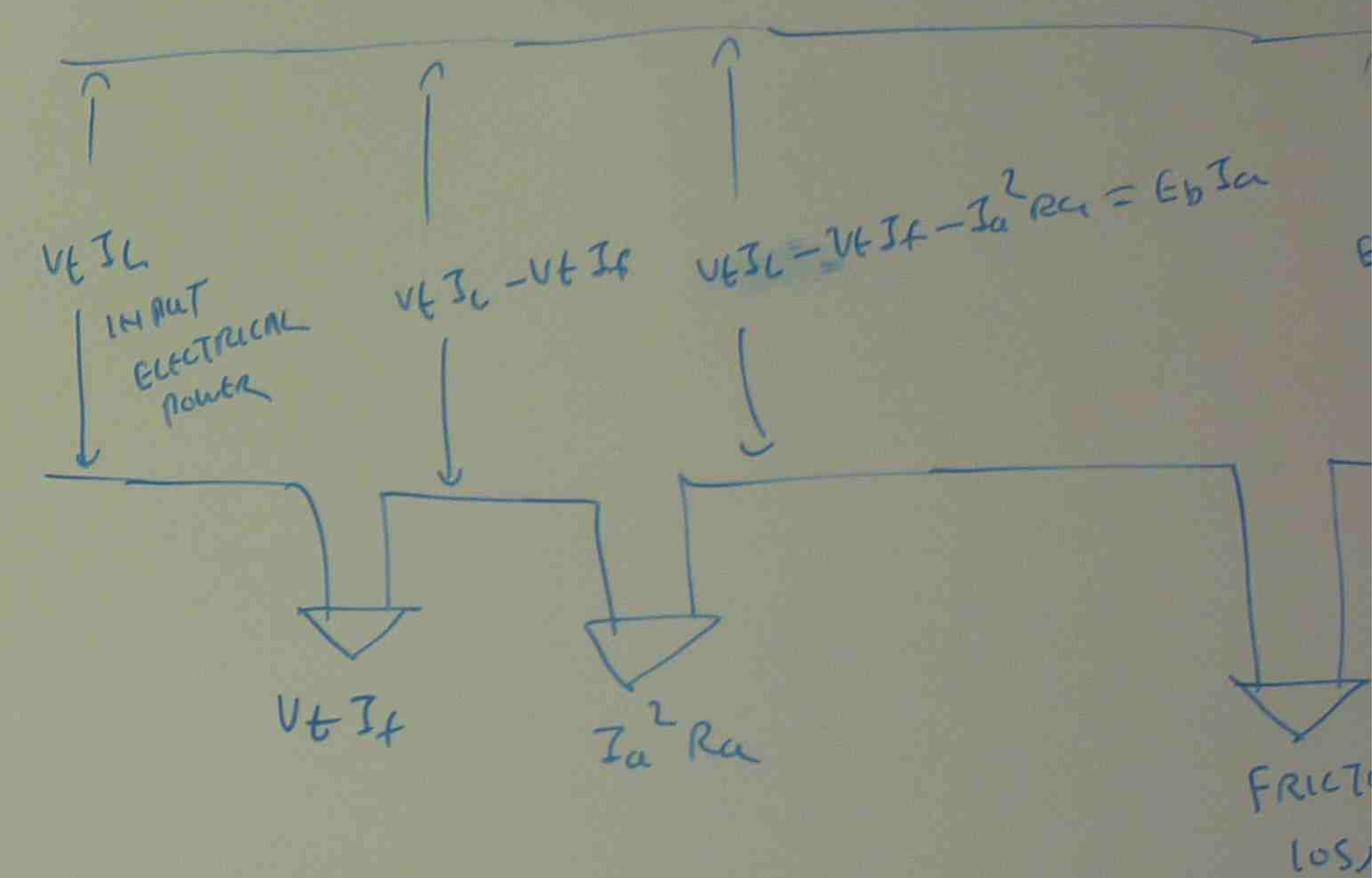
FLOW DIAGRAM IN DC GENERATOR

UT = $V_t \times I$

N = $E_g I_a$ + ROTATIONAL LOSSES



POWER FLOW DIAGRAM IN DC MOTOR



$$\eta \% = \frac{\text{OUTPUT}}{\text{INPUT}} \times 100 = \left(1 - \frac{\text{Power loss}}{P_{out} + P_{loss}}\right) \times 100$$