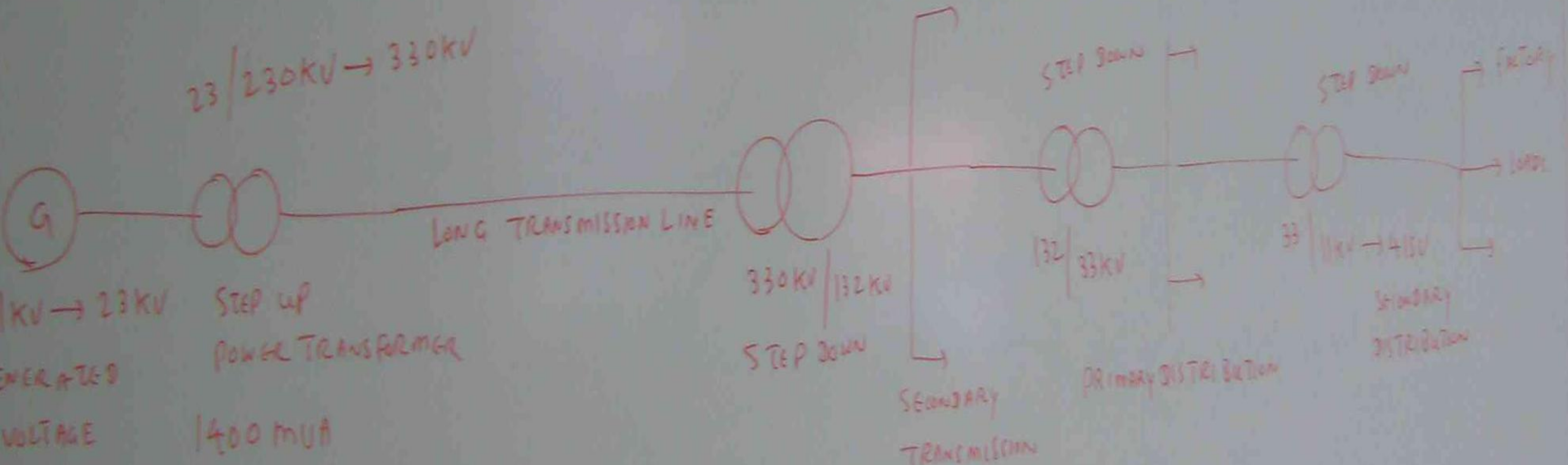
EENEEG040B DEVELOP ENGINEERING SOLUTIONS FOR ENERGY SUPPLY

POWER TRANSFORMER PROBLEMS

7762 AD

POWER TRANSFORMER



CONSTRUCTION, OPERATION, MAINTENANCE,

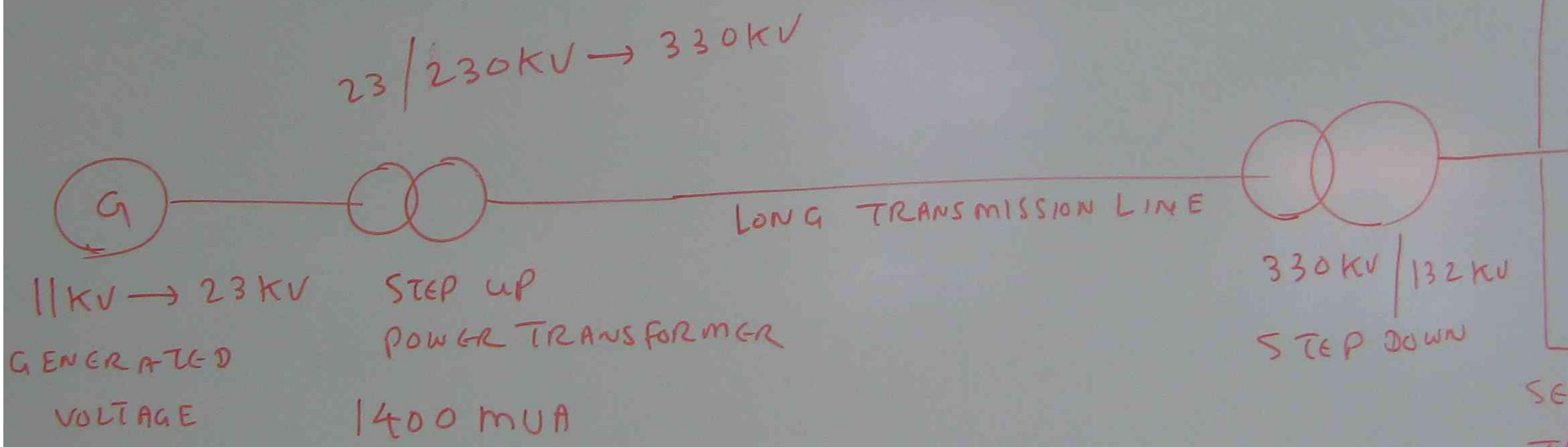
APPLICATION, FAULT FINDING, CHARACTRISTICS

UEENEEG 040B DEVELOP ENGINEERING SOLUTIONS FOR ENERGY SUPPLY

POWER TRANSFORMER PROBLEMS.

7762 AD

POWER TRANSFORMER

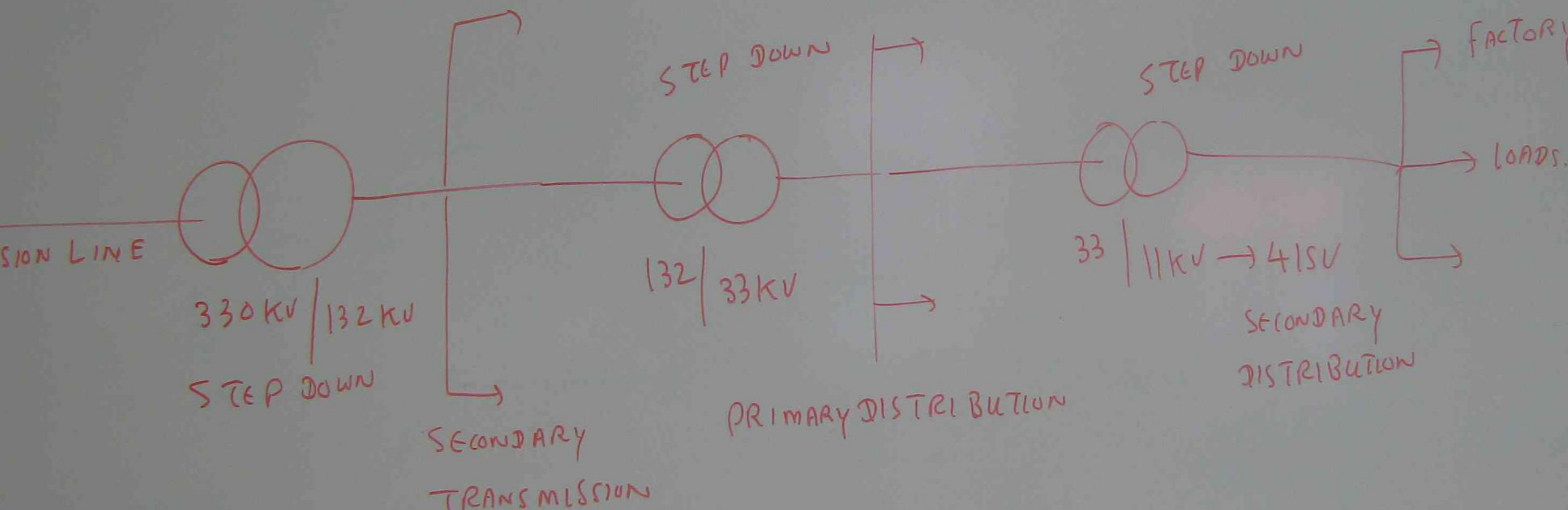


CONSTRUCTION, OPERATION, MAINTENANCE,

APPLICATION, FAULT FINDING, CHARACTERISTICS

OLUTIONS FOR ENERGY SUPPLY

LEMS.



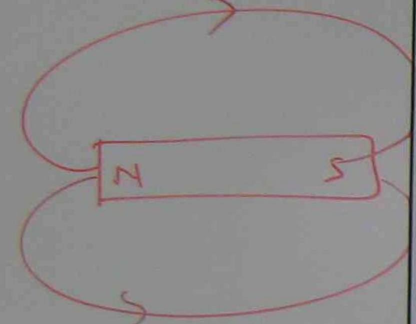
,

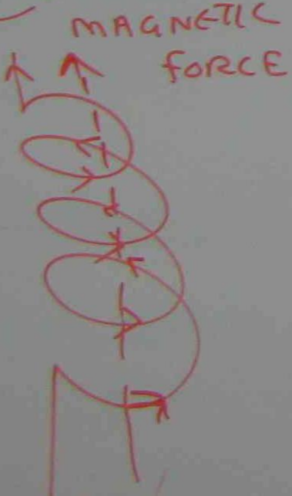
RISTICS

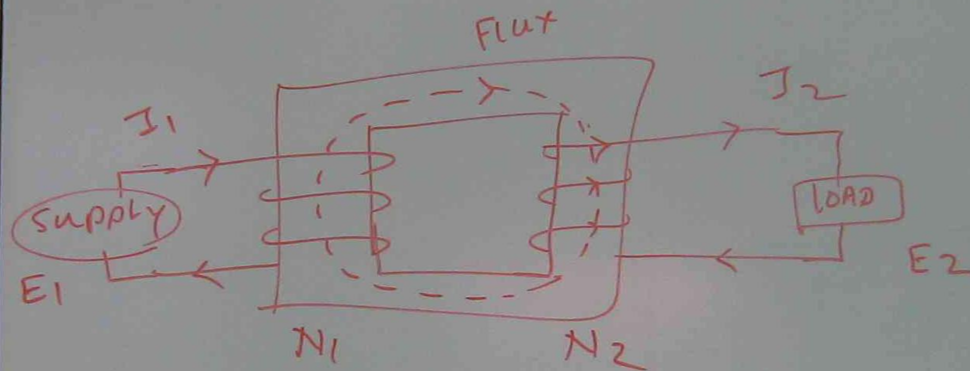
ORY

DS.

REVIEW STUDY ON MAGNETISM & TRANSFORMER







$$\boxed{\frac{E1}{E_2} = \frac{N1}{N_2} = \frac{I_2}{I_1} = a}$$

I_1 = PRIMARY CURRENT

I_2 = SECONDARY CURRENT

E_1 = PRIMARY VOLTAGE

E_2 = SECONDARY VOLTAGE

N_1 = PRIMARY NO. OF TURNS

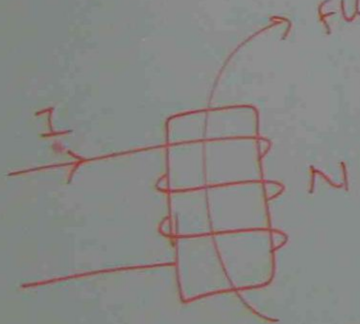
N_2 = SECONDARY NO. OF TURNS

FLUX DENSITY → DEPENDS ON KIND OF MAGNETIC MATERIALS

TEMPORARY MAGNET

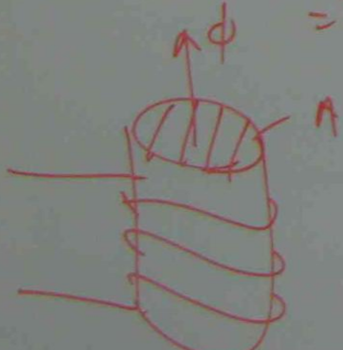
PERMANENT MAGNET

FLUX (ϕ)



MAGNETIC FORCE = N x I

= TURNS X CURRENT



$$\text{FLUX DENSITY} = \frac{\text{FLUX}}{\text{CORE CROSS SECTIONAL AREA}}$$

$$\boxed{\underset{(T)}{B} = \frac{\phi \quad wb}{A \quad m^2}}$$

T - TESLA

TRANSFORMER VOLTAGE EQUATION

$$\boxed{E = 4.44\ \phi\ f\ N}$$

$\phi = B.A$

E = VOLTAGE (VOLT)

ϕ = FLUX (wb)

f = FREQUENCY (Hz)

N = NO. OF TURNS.

ETIC MATERIALS

$$\boxed{\underset{(T)}{B} = \frac{\phi \quad wb}{A \quad m^2}}$$

T - TESLA

TRANSFORMER VOLTAGE EQUATION

$$\boxed{E = 4.44\,\phi\, f\, N}$$

$\phi = B.A$

E = VOLTAGE (VOLT)

ϕ = FLUX (wb)

f = FREQUENCY (Hz)

N = NO. OF TURNS.

PERMEABILITY

ELECTRICAL POWER → TRANSFORMER WINDING & CORE → MAGNETIC ENERGY

$$\mu = \frac{B}{H}$$

B — FLUX DENSITY

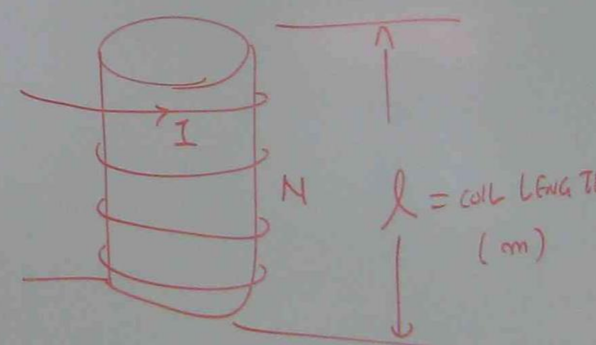
H — MAGNETIZING FORCE

μ — PERMEABILITY

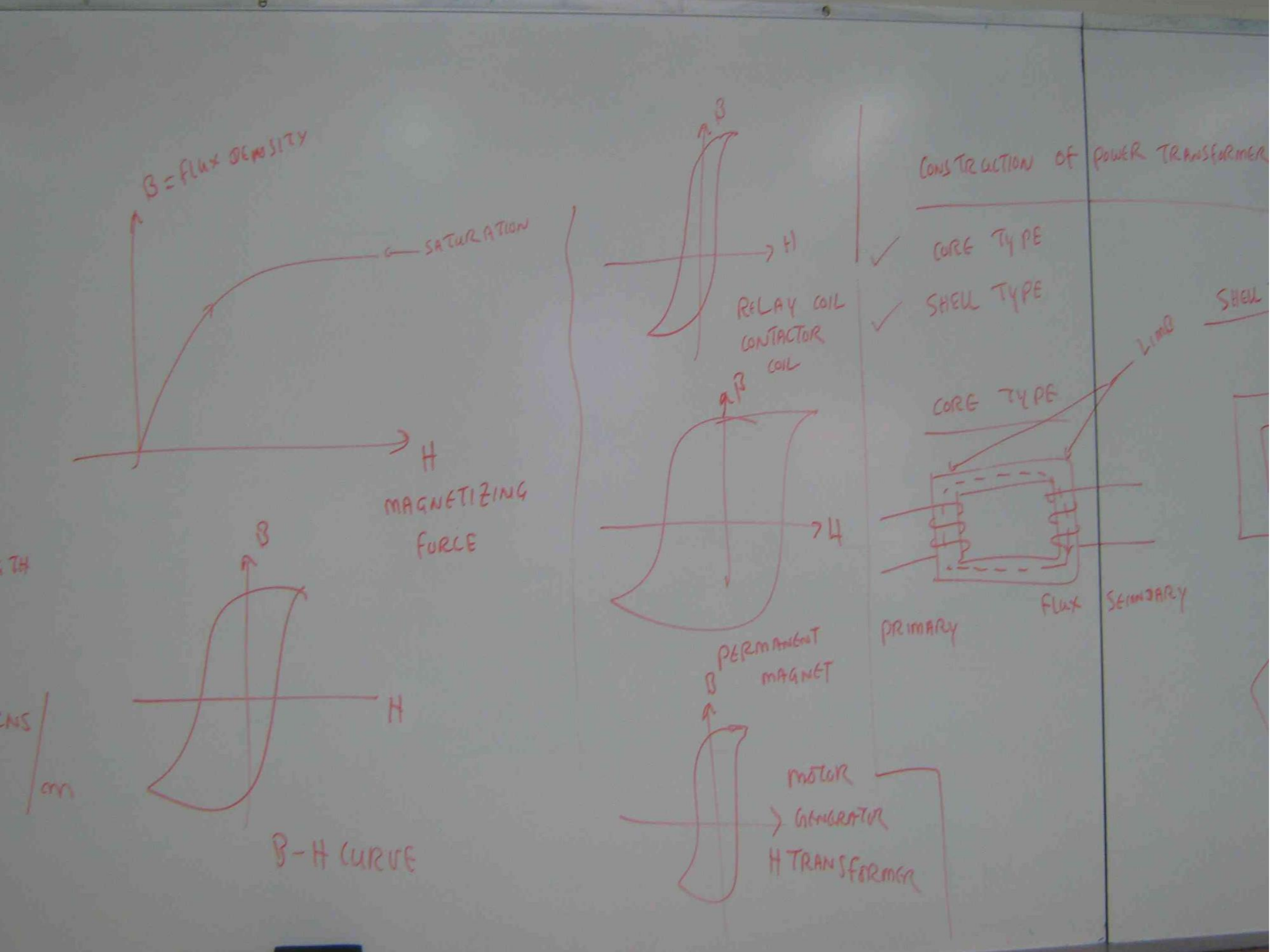
$$B = \frac{\phi}{A} = \frac{\text{FLUX (Wb)}}{\text{AREA } (m^2)}$$

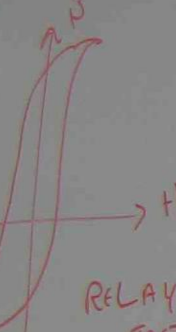
$$H = \frac{\text{AMPERE} \times \text{TURNS}}{\text{COIL LENGTH}}$$

H — MAGNETIZING FORCE

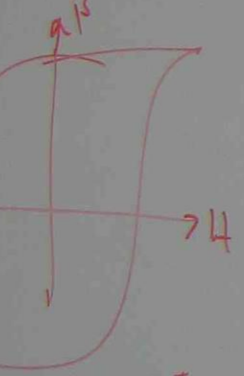


$$H = \frac{I \times N}{l} \quad \text{AMP-TURNS}/m$$


B = FLUX DENSITY
SATURATION
H
MAGNETIZING FORCE
B
H
B-H CURVE
B
H
RELAY COIL
CONTACTOR COIL
B
H
PERMANENT MAGNET
B
MOTOR
GENERATOR
H TRANSFORMER
CONSTRUCTION OF POWER TRANSFORMER
CORE TYPE
SHELL TYPE
CORE TYPE
LIMB
FLUX
SECONDARY
PRIMARY
SHELL



RELAY COIL
CONTACTOR COIL



PERMANENT MAGNET

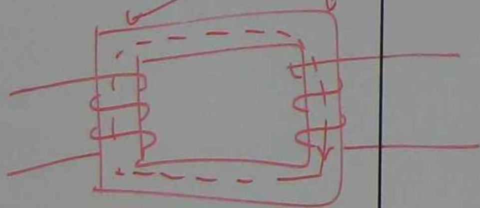
MOTOR
GENERATOR
TRANSFORMER

CONSTRUCTION OF POWER TRANSFORMER

- ✓ CORE TYPE
- ✓ SHELL TYPE

CORE TYPE

LIMB



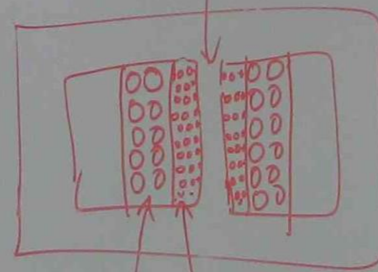
PRIMARY

FLUX

SECONDARY

SHELL TYPE

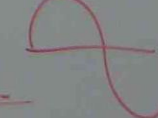
CENTRE LIMB



H.V WINDING ⟨H.V, LOW CURRENT⟩

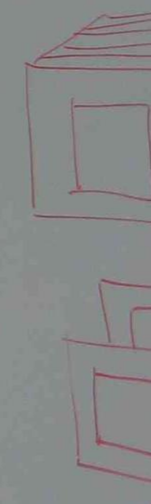
⟨L.V WINDING HIGH CURRENT⟩

HARMONICS



CONSTRUCTION

LAMINATED

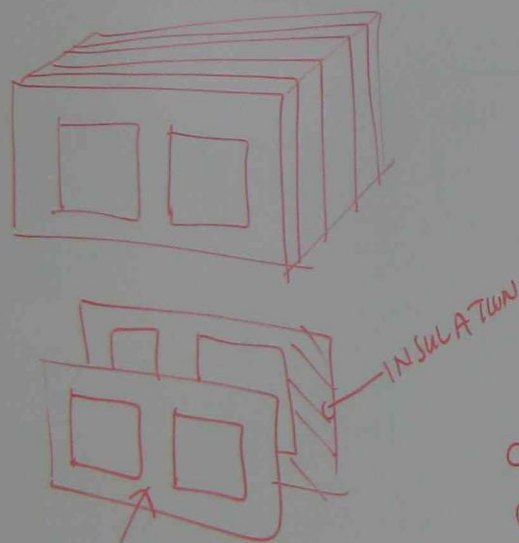


IRO

5 LIMB COR

CONSTRUCTION OF TRANSFORMER CORE

LAMINATED IRON CORE



BY USING THE LAMINATED CORE, TRANSFORMER LOSSES CAN BE REDUCED.

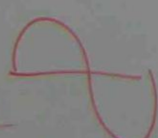
HYSTERESIS LOSS

CAUSED BY CHANGE OF MAGNETIC FIELD

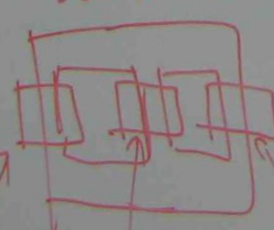
EDDY CURRENT LOSS

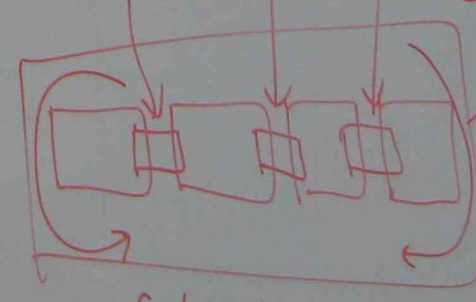
CAUSED BY CIRCULATING CURRENT.

5 LIMB CORES



3 LIMB CORE





5 LIMBS CORE

-OW
URRENT >

ARMONICS

UP

MON

5:30

8

1

TUE

5:

WE

THU

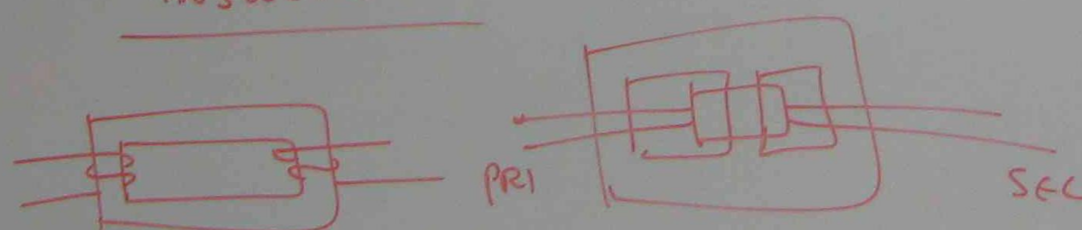
FR

TUTORIAL

1. SKETCH CORE TYPE AND SHELL TYPE TRANSFORMER.
2. WHY LAMINATED CORE IS USED IN TRANSFORMER
3. DIFFERENTIATE BETWEEN GENERAL TRANSFORMER AND ENERGY SUPPLY TRANSFORMER IN THE ASPECT OF CONSTRUCTION AND OPERATION.

ANSWER

1.



CORE TYPE SHELL TYPE

(3)

2 LAMINATED CORE IS USED TO REDUCE EDDY CURRENT LOSS AND HYSTERESIS LOSS IN POWER TRANSFORMER

3 GENERAL TRANSFORMER AND ENERGY SUPPLY POWER TRANSFORMER

HAVE (1) THE SAME BASIC PRINCIPLE OF OPERATION

(2) THE SAME BASIC CONSTRUCTION

BUT THE DIFFERENCES ARE

(1) NATURAL AIR COOLING IS SUFFICIENT FOR GENERAL TRANSFORMER - FORCED AIR, FORCED OIL, STILL OIL COOLING SYSTEMS ARE REQUIRED FOR ENERGY SUPPLY POWER TRANSFORMER

(2) APPROPRIATE PROTECTION SYSTEM SUCH AS BUCHHOLZ RELAY (GAS OPERATED RELAY) FOR INTERNAL FAULT, DIFFERENTIAL RELAY FOR ELECTRICAL LEAKAGE ARE [illegible] FOR ENERGY SUPPLY TRANSFORMER.

(3) HARMONICS IS VERY SERIOUS IN POWER SUPPLY NETWORKS.

HARMONICS CAN DETEORIATE THE INSULATIONS AND SHORTEN THE MACHINE LIFE

IT CAN ALSO CAUSE VIBRATIONS IN BIG ROTATING MACHINES

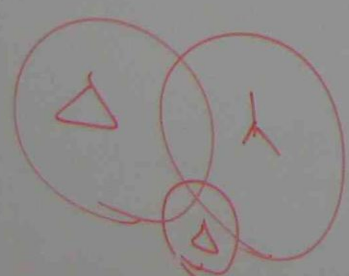
IN ENERGY SUPPLY TRANSFORMERS, THE FOLLOWING METHODS ARE UTILIZED

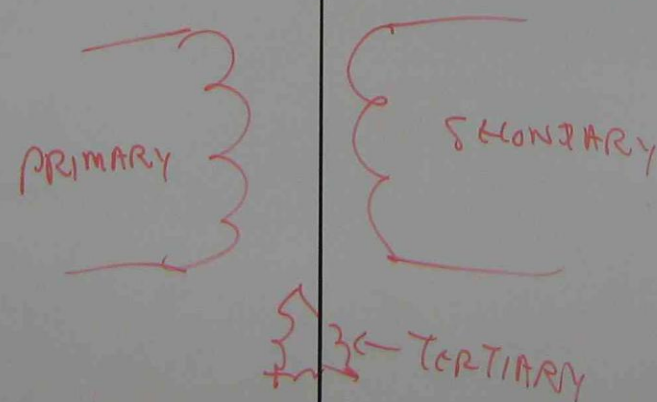
⟨a⟩ USE OF 5 LIMBS CORE FOR 3ϕ TRANSFORMER HARMONIC RETURN PATH

⟨b⟩ USE OF TERTIARY WINDING.

POWER QUALITY

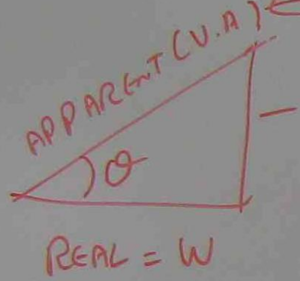
www.esipowersystem.zoomshare.com





TRANSFORMER RATING

MACHINE RATING



θ = POWER FACTOR ANGLE

$\cos\theta$ = POWER FACTOR

WATT = V.A $\cos\theta$ 1ϕ

WATT = $\sqrt{3}$ V.A $\cos\theta$ 3ϕ

TRANSFORMER RATING

- VOLTAGE
- CURRENT
- POWER (V.A)

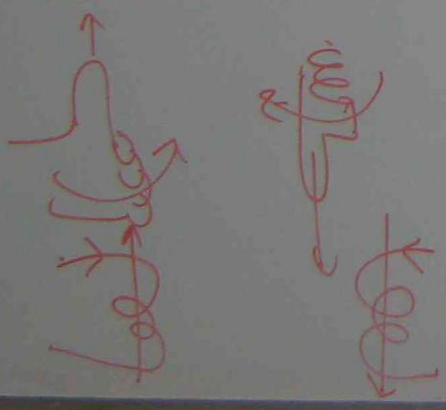
300KVA 900KVA

PARALLEL OPERATION POWER TRANSFORMERS

- POLARITY
- SAME VOLTAGE
- SAME FREQUENCY
- SAME PHASE SEQUENCE

POLARITY OF TRANSFORMER IS DETERMINED BY WINDING

DIRECTION



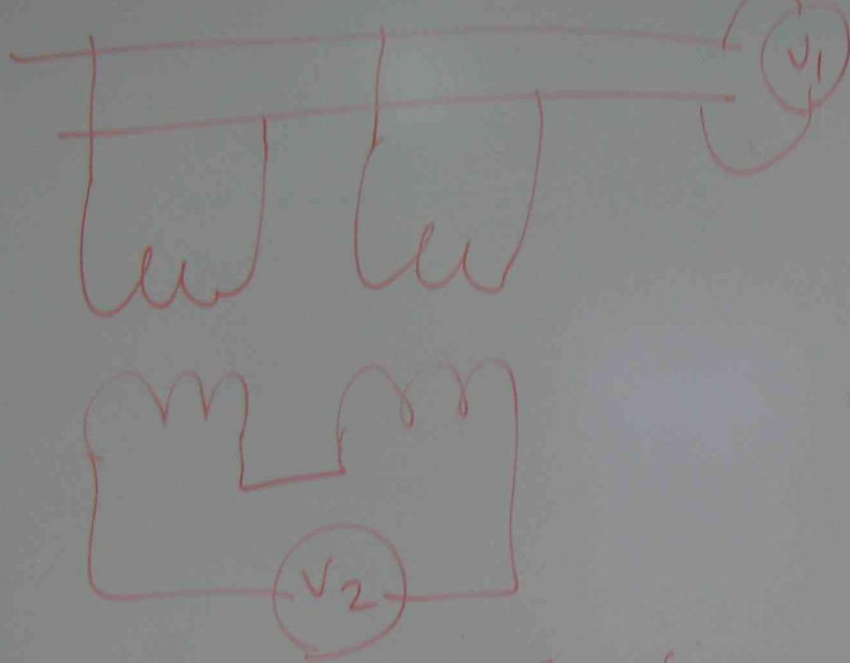
POLARITY

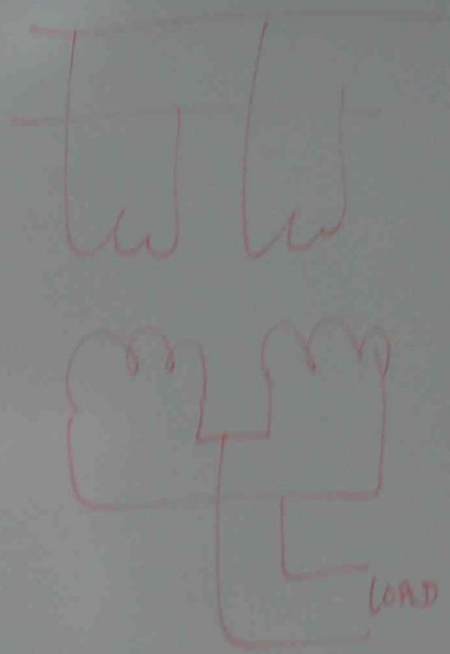
ME VOLTAGE

E FREQUENCY

PHASE

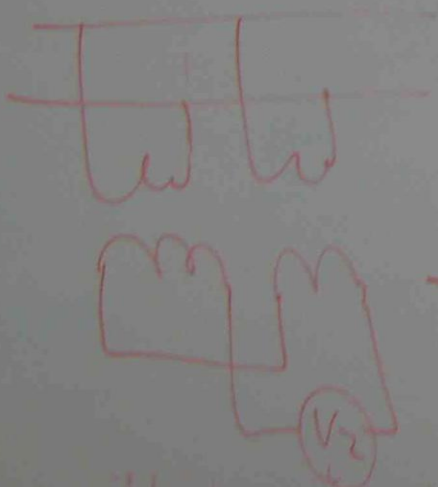
UENCE

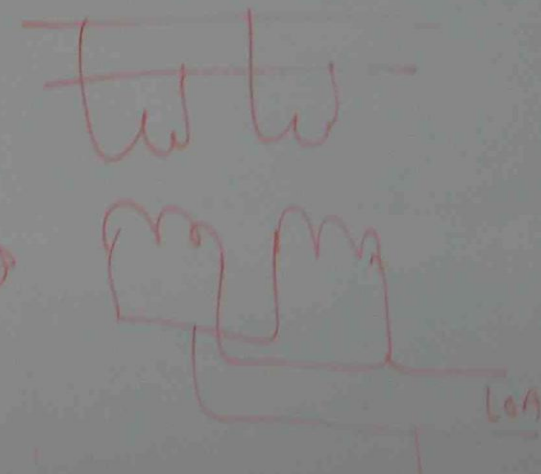




IF $V_2 \simeq 0$

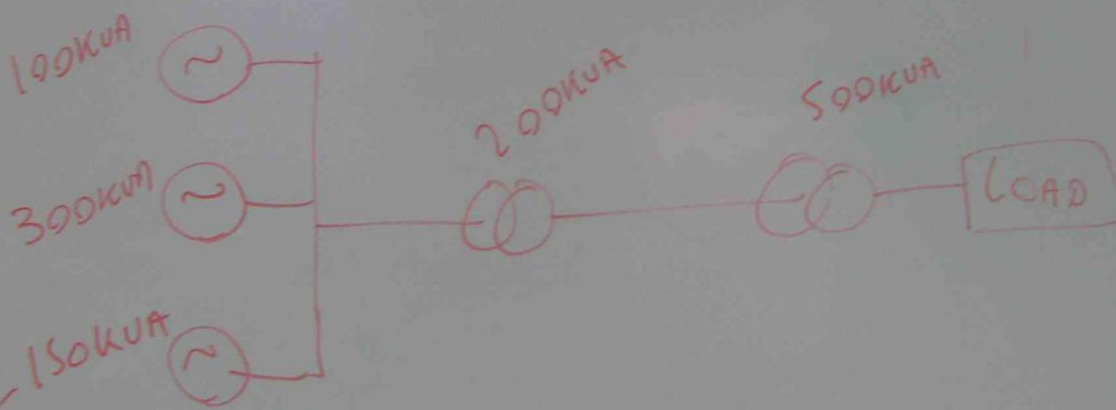
IF $V_2 \neq 0$





PER UNIT SYSTEM

$$\text{PU RATING} = \frac{\text{MACHINE V.A}}{\text{BASE V.A}}$$



$$\frac{150}{300} = 0.5\,\text{pu}$$

300KVA = BASE 

$$150\,\text{KVA} = \frac{150\,\text{KVA}}{\text{BASE } 300\,\text{KVA}} = 0.5\,\text{pu}$$

P.U SYSTEM IS APPLIED FOR PARALLELING POWER TRANSFORMERS.

TO EQUALIZE IMPEDANCES.

---

pb ①

PRIMARY TURNS = 350

PRIMARY VOLTAGE = 2200 V rms

FREQUENCY = 50 HZ

C.S.A = 250 cm², LENGTH OF WINDING = 125 cm.

CALCULATE MAGNETIC FLUX DENSITY OF ABOVE 1ϕ TRANSFORMER

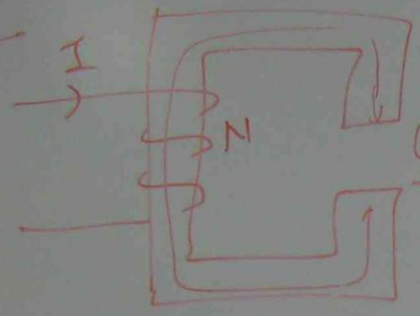
$$E = 4.44\,\phi f N$$

$$2200 = 4.44 \times \phi \times 50 \times 350$$

$$\phi = \frac{2200}{4.44 \times 50 \times 350} = 0.0276 \text{ wb}$$

$$B = \frac{\phi}{A} = \frac{0.0276}{250 \times (10^{-2})^2} = 1.1\text{T}$$

pb (2)



CORE LENGTH = 1250 mm

AIR GAP LENGTH = 0.15 mm

MAGNETIC FLUX DENSITY = 1.1T

μ_r FOR STEEL = 1800

$\mu_0 = 4\pi \times 10^{-7}$

N = 350

I = ?

CALCULATE (a) TOTAL MAGNETIZING FORCE

(b) IF NO. OF TURNS ON CORE IS 350, CALCULATE I_{max} & I_{rms} REQUIRED FOR THE COIL.

$B = 1.1\,T$

$\boxed{B = \mu H}$

$\mu = \mu_0 \mu_r$

$H = \dfrac{B}{\mu}$

$$NI = \sum HL = H_{CORE} L_{CORE} + H_{AIR\,GAP} L_{AIR\,GAP}$$

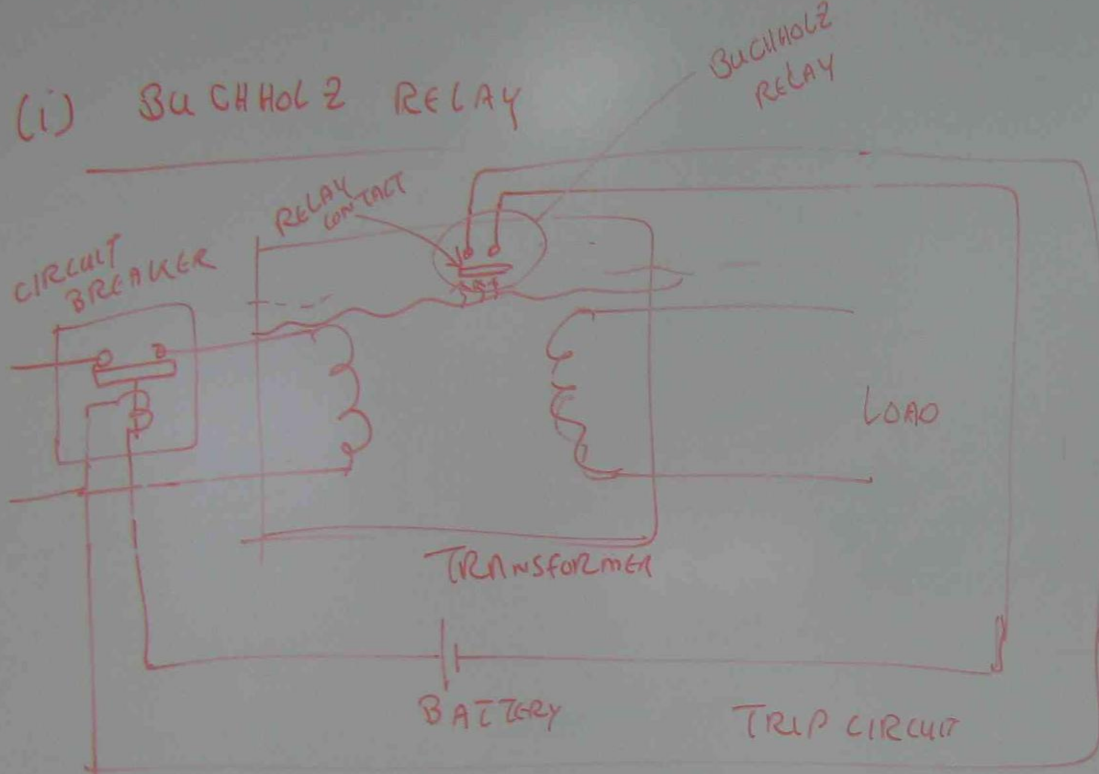
$$350 \times I = \frac{B_{CORE}}{\mu_0 \mu_{r\,CORE}} \times L_{CORE} + \frac{B_{AIR\,GAP}}{\mu_0 \mu_{r\,AIR\,GAP}} \times L_{AIR\,GAP}$$

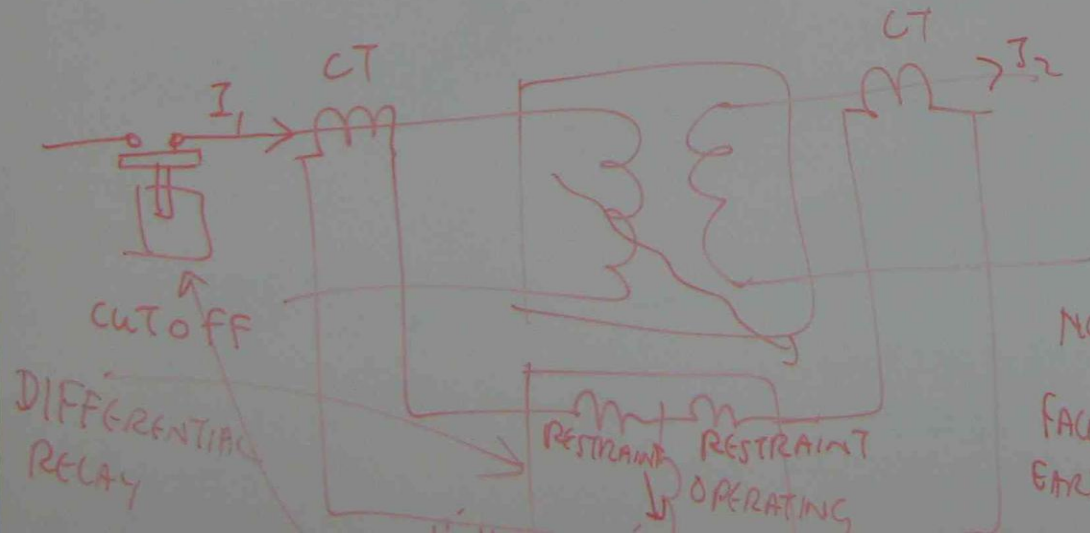
$$350 \times I = \frac{1.1}{4\pi \times 10^{-7} \times 1800} \times \frac{1250}{1000} + \frac{1.1}{4\pi \times 10^{-7} \times 1} \times \frac{0.15}{1000}$$

$$I_{MAX} = 2.16 \text{ Amp}$$

$$I_{rms} = \frac{I_{MAX}}{\sqrt{2}} = \frac{2.16}{1.4142} = 1.53 \text{ Amp.}$$

(i) BUCHHOLZ RELAY





NORMAL $I_1 = I_2 \times a$

FAULT EARTH LEAKAGE $I_1 \neq I_2 a$

TUTORIAL

DERIVE $E_{RMS} = 4.4$

$V = V_{max} \sin \omega t$

$\phi = \phi_{max} \sin (\omega t$

INDUCED VOLTAGE

$e = - N \times \frac{d\phi}{dt}$

$= - N \times \frac{d}{dt} ($

$= - N \times \phi_{max} \frac{d}{dt}$

$= - N \times \phi_{max} (-$

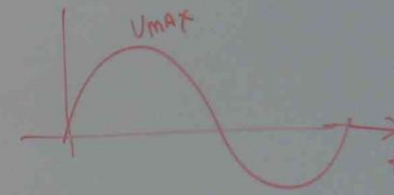
$e = N \phi_{max} \omega$

$(\leftarrow e_{max} \rightarrow)$

TUTORIAL

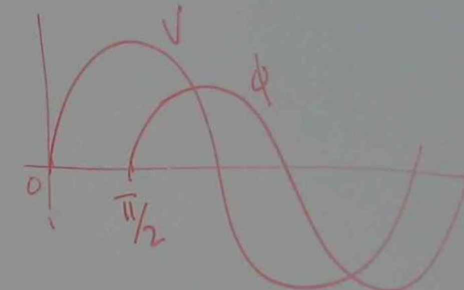
DERIVE $E_{RMS} = 4.44\ \phi\ f\ N$

$\omega = 2\pi f$



$V = V_{MAX} \sin \omega t$

$\phi = \phi_{MAX} \sin\left(\omega t - \pi/2\right)$



INDUCED VOLTAGE

$$e = -N \times \frac{d\phi}{dt}$$

$$= -N \times \frac{d}{dt}\left(\phi_{max} \sin(\omega t - \pi/2)\right)$$

$$= -N \times \phi_{max} \frac{d}{dt}\left[\sin\omega t \underbrace{\cos \pi/2}_{0} - \cos\omega t \sin \pi/2\right]$$

$$= -N \times \phi_{max} (-)\, \omega \cdot \sin\omega t$$

$$e = \underbrace{N \phi_{max}\, \omega}_{e_{max}} \sin\omega t$$

$\sin(A-B) = \sin A \cos B - \cos A \sin B$

$$e_{max} = N \phi_{max} \times \omega$$

$$= N \phi \times 2\pi f$$

$$e_{rms} = \frac{N\phi \times 2 \times 3.1416 f}{1.4142}$$

$$= 4.44 N \phi f$$

$= I_2 \times a$

$I_1 \neq I_2 a$