Unit 2 - Week1

Week 1: Assignment

Assignment-1

1) A cast-steel ring has a mean circumference of 80 cm and a cross-sectional area of 3.14 cm^2. An air – gap of 1mm length is cut-out in the ring. The ring is wound uniformly with a coil of 600 turns. Calculate the flux produced in the air – gap, if the exciting current is 2A? Neglect fringing and leakage. ***10 points***

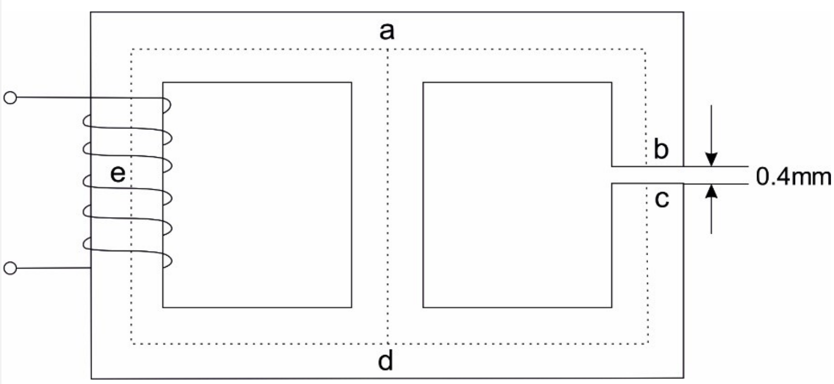
Magnetization data:

H(AT/m)	200	400	600	800	1000	1200	1400	1600	1800	2000
B (T)	0.10	0.32	0.60	0.90	1.08	1.18	1.27	1.32	1.36	1.40

- 1.3 Wb
- 0.26 mWb
- 6.2 mWb
- 4.8 mWb

Accepted Answers:
0.26 mWb

2) The magnetic circuit, made out of mild steel core is shown in figure. ***10 points***

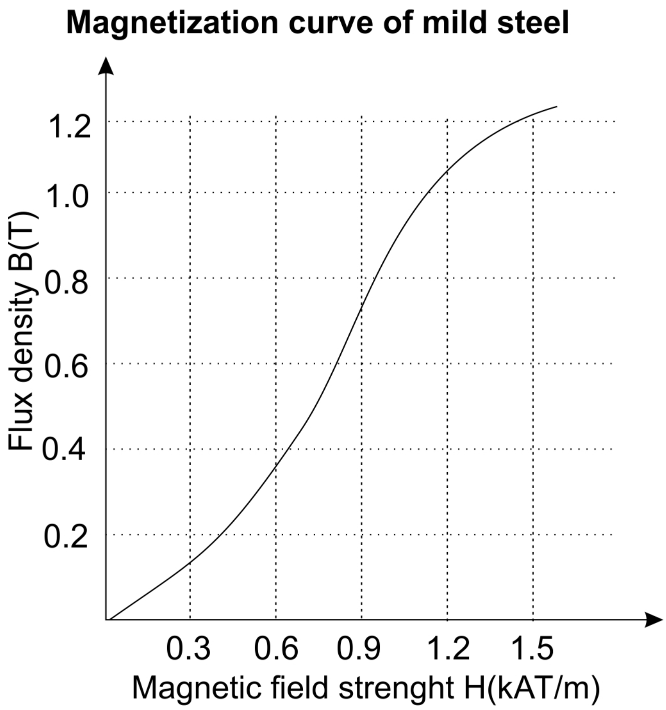


The dimensions are given below:

Length (ab + cd) = 40 cm Cross-sectional area = 30 cm^2
Length ad = 20 cm Cross-sectional area = 30 cm^2
Length aed = 40 cm Cross-sectional area = 30 cm^2

Determine the exciting coil mmf required to establish an air-gap flux of 0.6 m

Wb. Neglect fringing and leakage.
The magnetization curve of mild steel is given below:



- 470 AT
- 207 AT
- 803 AT
- 1252 AT

Accepted Answers:
803 AT

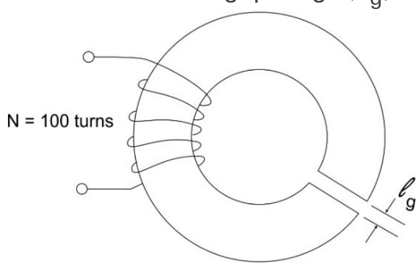
3) The magnetic circuit shown in figure, has the following parameters **10 points**

N = 100 turns

Core area, A_c = Air gap area, A_g = 5 cm^2

Relative permeability of core , μ_{core} = infinity

Determine the air-gap length, l_g, to provide a coil inductance of 10 mH.



- 1 cm
- 2 mm
- 0.1 mm
- 0.6 mm

Accepted Answers:
0.6 mm

4) The primary of a transformer has 200 turns and is excited by a 50 hz, 230 – V source. **10 points**

What is the maximum value of the core flux?

- 40.8 mWb
- 5.18 mWb
- 7 mWb
- 4 mWb

Accepted Answers:
5.18 mWb

5) A voltage v = 166 sin(314t) + 20sin(942t) V is applied to the primary of a transformer. If the transformer has 100 turns in the primary, determine the rms value of the core flux. The leakage flux can be neglected. ***10 points***

- 4.6 mWb
- 3.7 mWb
- 2.8 mWb
- 8.3 mWb

Accepted Answers:
3.7 mWb

6) A 20 – kVA, 50 – Hz,2000/200 V distribution transformer has a leakage impedance of 0.42 + j 0.52Ω in the high-voltage (HV) winding and 0.002 + j0.05 Ω in the low-voltage (LV) winding. It is employed to step down the voltage at the load-end of a feeder having an impedance of 0.15 + j 1.8 Ω. The sending-end voltage of the feeder is 2 kV. Find the voltage at the load end of the transformer when the load is drawing rated transformer current at 0.8 pf lagging. The voltage drops due to exciting current may be ignored. ***10 points***

- 195V
- 180V
- 133V
- 188V

Accepted Answers:
195V

7) A single-phase 33kVA, 1100/110 V, 50 Hz transformer has the following parameters: ***10 points***

Primary winding (HV side)-Resistance=2 Ω, leakage Reactance=6.2 Ω

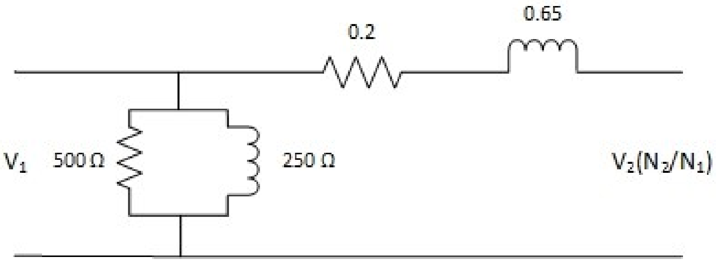
Secondary winding (HV side)-Resistance=0.05 Ω, leakage Reactance=0.06 Ω

Find the equivalent resistance and equivalent leakage reactance referred to primary

- 7 ohm and 12.2 ohm
- 10 ohm and 12.2 ohm
- 7 ohm and 15 ohm
- 10 ohm and 15 ohm

Accepted Answers:
7 ohm and 12.2 ohm

8) The equivalent circuit of a 250/2500 V transformer referred to the low voltage side is given below. ***10 points***

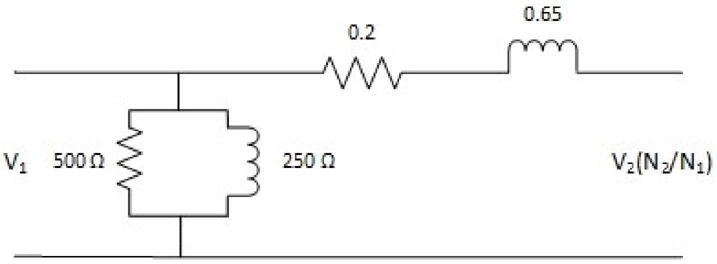


A load of 350+j210 Ω is connected. For a primary side input voltage of 250 V, compute the RMS value of primary current.

- 68 A
- 38 A
- 54 A
- 60 A

Accepted Answers:
54 A

9) The equivalent circuit of a 250/2500 V transformer referred to the low voltage side is given ***10 points*** below.



A load of 350+j210 Ω is connected. For a primary side input voltage of 250 V, compute the input power factor

- 0.68 lag
- 0.68 lead
- 0.81 lag
- 0.81 lead

Accepted Answers:
0.81 lag

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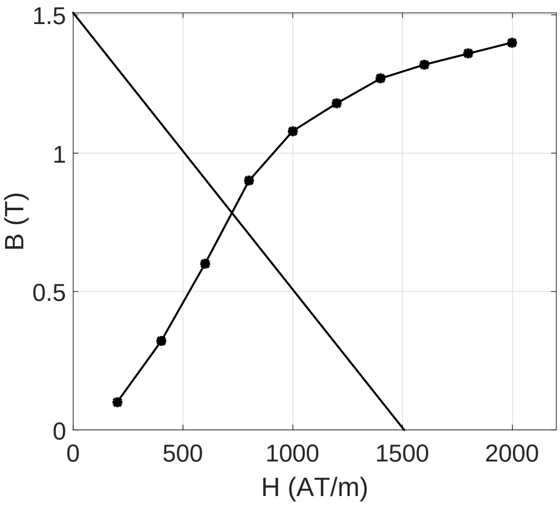
Assignment - 1 : Solution

Q1. Solution

$$l_c = 0.8m; \quad l_g = 10^{-3}; m \quad A_c = 3.14 \times 10^{-4} m^2; \quad N = 600; \quad i = 2A$$
$$Ni = H_c l_c + H_g l_g$$
$$= H_c l_c + \frac{B_g}{\mu_o} l_g$$
$$no.\ fringing \quad B_g = B_c$$
$$Ni = H_c l_c + \frac{B_c}{\mu_o} l_g$$
$$B_c = -\left(\frac{\mu_o l_c}{l_g}\right) H_c + \left(\frac{\mu_o N i}{l_g}\right)$$
$$B_c = -\left(\frac{4\pi \times 10^{-7} \times 0.8}{10^{-3}}\right) H_c + \left(\frac{4\pi \times 10^{-7} \times 600 \times 2}{10^{-3}}\right)$$
$$B_c = (-1.005 \times 10^{-3}) H_c + 1.507$$

This equation is in the form of a straight line. It can be plotted over the B-H curve of the core material . The intersecting point gives the operating point.



From the plot

$$B_c = 0.79T$$
$$\phi = 0.79 \times A_c$$
$$= 0.79 \times 3.14 \times 10^{-4}$$
$$= 0.258 mWb$$

Q2.Solution

Air gap flux required = $0.6mWb$ Assuming no fringing, the flux density in the path abcd will be same as that in the air gap.

$$B = \frac{0.6 \times 10^{-3}}{30 \times 10^{-4}} = 0.2T$$

$$\text{mmf. across air gap :} \quad F_{bc} = \frac{B}{\mu_o} l_{bc} = \frac{0.2 \times 0.4 \times 10^{-3}}{4\pi \times 10^{-7}}$$

$$= 63.6AT$$

$$\text{From the BH-curve of cast-steel for B = } 0.2T; \quad H_c = 400AT/m$$

$$H_{ab} = H_{cd}$$

$$F_{ab+cd} = 400 \times 40 \times 10^{-2}$$

$$= 160AT$$

$$F_{ad} = F_{bc} + F_{ab} + F_{cd}$$

$$= 160 + 63.66 = 223.6AT$$

$$H_{ad} = \frac{F_{ad}}{l_{ad}} = \frac{223.6}{20 \times 10^{-2}} = 1118AT/m$$

$$\text{From the BH-Curve, for a flux density of 1118 AT, } B_{ad} = 1T$$

$$\phi_{ad} = 1 \times 30 \times 10^{-4} = 3mWb$$

$$\phi_{dea} = \phi_{ad} + \phi_{abcd}$$

$$= 0.6 + 3 = 3.6mWb$$

$$B_{dea} = \frac{3.6 \times 10^{-3}}{30 \times 10^{-4}} = 1.2T$$

$$\text{From BH-Curve,} \quad H_{dea} = 1450AT/m$$

$$F_{dea} = H_{dea} l_{dea} = 1450 \times 40 \times 10^{-2} = 580AT$$

$$\text{Coil mmf required, } F = F_{dea} + F_{ad} = 580 + 223.6$$

$$= 803.6AT$$

Q3.Solution

$$N = 100turns; \quad A_c = A_g = 5 \times 10^{-4}; \quad \mu_{core}$$

$$\mu_{core} = \infty \Rightarrow reluctance, R_c = 0$$

$$\text{Required coil inductance, } L = 10mH$$

$$R_g = \frac{l_g}{\mu_o A_g}$$

$$L = \frac{N^2}{R_g} = \frac{N^2 \times 4\pi \times 10^{-7} \times 5 \times 10^{-4}}{l_g}$$

$$l_g = \frac{100^2 \times 4\pi \times 10^{-7} \times 5 \times 10^{-4}}{10 \times 10^{-3}}$$

$$= 0.6mm$$

Q4.Solution

$$E_1 = 4.44 f N_1 \phi_m \tag{1}$$

$$\phi_m = \frac{E_1}{4.44 f N_1} \tag{2}$$

$$= \frac{230}{4.44 \times 50 \times 200} \tag{3}$$

$$= 5.18\ mWb \tag{4}$$

Q5.Solution

$$\phi = \frac{1}{N} \int v dt \tag{5}$$

$$= \frac{1}{100} \int (166 \sin(314t) + 20 \sin(942t)) dt \tag{6}$$

$$= -5.28 \cos(314t) - 0.21 \cos(942t) \ \ mWb \tag{7}$$

$$\phi_{rms} = \sqrt{\left(\frac{5.28}{\sqrt{2}}\right)^2 + \left(\frac{0.21}{\sqrt{2}}\right)^2} \tag{8}$$

$$= 3.73\ mWb \tag{9}$$

Q6.Solution

The approximate equivalent circuit referred to the HV side with the feeder impedance is shown in Fig.1

$$\text{Rated load current (HV Side)} = \frac{20 \times 10^3}{2000} = 10A$$

$$\text{Transformer impedance referred to HV side, } Z_{trans} = (0.42 + j0.52) + 10^2(0.002 + j0.05)$$

$$= 0.62 + j5.52\ \Omega$$

The feeder being in the HV side of the transformer, its impedance is not modified

$$Z_{feeder} = 0.15 + j1.8\ \Omega$$

$$\text{Voltage at the load end referred to HV side, } V_L^{''} = 2000 - [(0.15 + 0.62) + j(1.8 + 5.52)] \times 10\angle - 36.86$$

$$= 1950.675\angle - 1.5847$$

$$\text{Load voltage referred to LV side, } V_L = \frac{1950.675}{10} = 195.07V$$

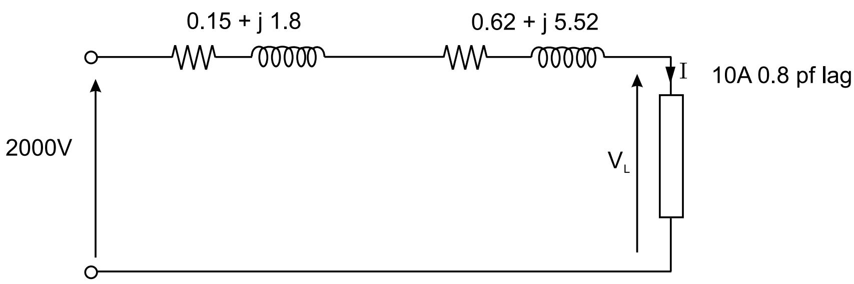


Figure 1: Equivalent circuit referred to HV side (Transformer + Feeder)

Q7.Solution

The voltage rating of the given transformer(V) = 2300/220 V

Frequency(f)=50Hz

EMF/turn=13 V

Flux density(B)=1.5 T

Therefore from the given data, no of turns in the primary of the transformer is given by= 2300/13 = 176.923 turns $\approx$ 177

$$E_1 = 4.44 f N_1 \phi_m$$

$$\phi_m = \frac{E_1}{4.44 f N_1}$$

$$= \frac{2300}{4.44 \times 50 \times 177}$$

$$= 58.56\, mWb$$

$$B = \frac{\phi_m}{\text{Area of cross section}}$$

$$\text{Area of cross section} = \frac{\phi_m}{B}$$

$$= \frac{58.56\, m}{1.5}$$

$$= 0.039\, m^2$$

Q8.Solution

The voltage rating of the given transformer(V) = 1100/110 V

Primary winding (HV side) parameters:-

$$R_1 = 2\ \Omega; X_1 = 6.2\ \Omega$$

Secondary winding (LV side) parameters:-

$$R_2 = 0.05\ \Omega; X_2 = 0.06\ \Omega$$

$$\text{Turns ratio(K)} = \frac{N_2}{N_1} = \frac{V_2}{V_1}$$

$$K = \frac{110}{1100} = \frac{1}{10}$$

Equivalent resistance referred to primary $R_{1eq} = R_1 + R_2^{'}$

$$R_2^{'} = \frac{R_2}{K^2}$$

$$= \frac{0.05}{\frac{1}{10}^2} = 5\ \Omega$$

$$R_{1eq} = 7\ \Omega$$

Equivalent reactance referred to primary $X_{1eq} = X_1 + X_2^{'}$

$$X_2^{'} = \frac{X_2}{K^2}$$

$$= \frac{0.06}{\frac{1}{10}^2} = 6\ \Omega$$

$$X_{1eq} = 12.2\ \Omega$$

Q9.Solution

The equivalent impedance of load referred to primary $(Z^{'}) = \left(\frac{N_1}{N_2}\right)^2 \times Z$

$$= \left(\frac{250}{2500}\right)^2 \times (350 + 210j) = (3.5 + 2.1j)\ \Omega$$

The total current drawn I_1 can be divided into two components.

One the shunt component I_e and the load component $I_1^{'}$

$$I_1 = I_e + I_1^{'}$$

$$I_e = \left(\frac{250}{500}\right) + \left(\frac{250}{250}\right)j = (0.5 + 1j) = 1.118\angle 63.44A$$

$$I_1^{'} = \frac{250}{(0.2 + 0.65j) + (3.5 + 2.1j)}$$

$$= 54.22\angle -36.62A$$

$$\therefore I_1 = 54.036\angle -35.453A$$

Q10.Solution

$$\text{Input power factor} = cos(-35.453) = 0.815lag$$