BITS, PILANI – DUBAI CAMPUS,
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
SECOND SEMESTER 2012 – 2013
ES C272 ELECTRICAL SCIENCES II
COMPREHENSIVE EXAMINATION (CLOSED BOOK)

MAXIMUM MARKS: 40 WEIGHTAGE: 40%
DATE: 03.06.2013 DURATION: 3 HOURS

1) Find the input impedance for the circuit shown in figure .1 for
   (a) AB open circuited
   (b) AB connected through 5 Ω resistor.

[4 marks]

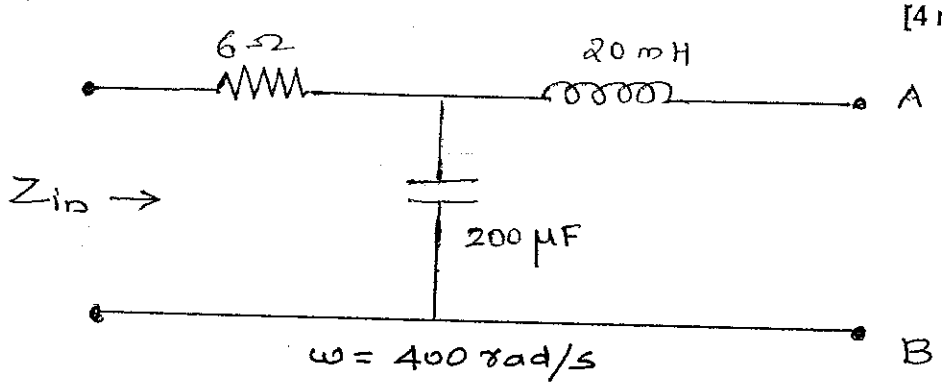


Figure 1

2) A pure inductive coil allows a current of 10 Amperes to flow from a 230V, 50Hz single phase supply. Find the (i) Inductive reactance (ii) Inductance (iii) Power absorbed. **[3 marks]**

3) An iron ring has a cross sectional area of 40mm^2 and a mean diameter of 25cm.It is wound with 500 turns having a relative permeability of 250.Calculate the total flux setup in the coil. The coil resistance is 474 Ω and supply voltage is 240V. **[4 marks]**

4) A 25 KVA, 2200/220 V, 50 Hz transformer has the following resistance and lekage reactance:

$R_{primary} = 08\Omega$ $X_{primary} = 3.2\ \Omega$

$R_{secondary}=0.009\Omega$ $X_{secondary}=0.03\Omega$

Calculate

(a) Equivalent resistance and reactance referred to primary side.

(b) Equivalent resistance and reactance referred to secondary side

[4 marks]

5) A 6 pole, 230V dc shunt motor has 238 wave connected conductors. It draws a field current of 0.9 A to give a no-load flux of 6.2 mWb. The armature resistance is 0.8 Ω. Calculate the motor speed at a no-load current of 2A.What would be the motor line current and speed when it develops a torque of 35 N-m?

[4 marks]

6) The efficiency of a 415 V,3-phase,4 pole induction motor drawing a line current of 80 A at 0.8 power factor at 3% slip is 75%.Determine the shaft output and shaft torque?

[3 marks]

7) A 4-pole, 50 Hz, 3-phase induction motor operates when running on full load develops a useful torque of 100Nm. Calculate

(a) Motor speed if slip = 4%.

(b) Frequency of rotor emf **[2 marks]**

8) With the help of a neat diagram, explain in detail the Torque-Slip characteristics of a 3-phase induction motor. **[4 marks]**

9) A10KW, 1500 rpm, 3-phase, 50Hz 440V synchronous motor has a stator resistance of 0.2Ω per phase, a field resistance of 35Ω and synchronous reactance of 2 Ω per phase. Calculate the shaft power output and field current for a stator input of 45KVA at 0.8 power factor leading. **[4 marks]**

Magnetization curve is linear with a slope of 85V line / field ampere.

10) Figure 2 shows a rectangular magnetic core with an air-gap. Find the exciting current needed to cause a flux density of B=1.2T in the air-gap. Given N=400 turns and μ_r (iron) =4000. **[4 marks]**

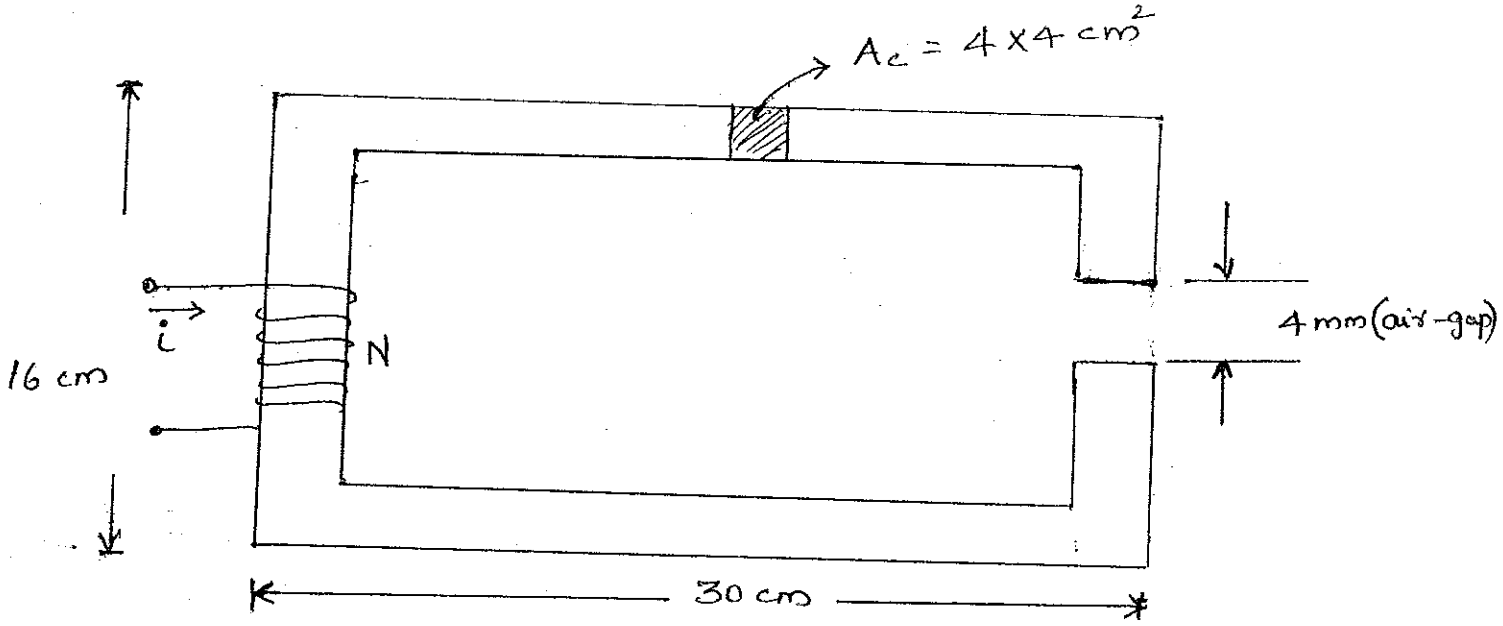


Figure 2

11) Write short notes on the following:

i. Synchronizing to main supply in Synchronous Generator.
ii. Circuit model of an ideal transformer. **[4 marks]**

03-06-2013

II-SEMESTER 2012-13

ES c272 ELECTRICAL SCIENCES-II

COMPREHENSIVE EXAMINATION ANSWER KEY

1) (a) AB open circuited

$$X_L = 400 \times 20 \times 10^{-3} = 8\,\Omega$$

$$X_C = \frac{10^6}{400 \times 200} = 12.5\,\Omega.$$

$$Z_{in} = (6 - j12.5) = 13.86 \angle -64.35\ \Omega$$

→ [2 MARKS]

(b) AB connected through 5 Ω resistor

$$Z_{in} = 6 + \frac{(5+j8)\cdot(-j12.5)}{5+j8-j12.5}$$

$$= 6 + \frac{117.9125 \angle -32}{5 - j4.5}$$

$$= 6 + \frac{117.9125 \angle -32}{6.72 \angle -41.98}$$

$$= 6 + 17.54 \angle 9.98^\circ$$

$$= 6 + 17.27 + j3.04$$

$$= 23.27 + j3.04.$$

$$= 23.46 \angle 7.4^\circ\ \Omega$$ → [2 MARKS]

2] (i) circuit current $I = V/X_L$

$\therefore$ Inductive reactance $X_L = \frac{V}{I} = \frac{230}{10} = 23\,\Omega$

↳ [1 M]

(ii) $X_L = 2\pi f L$

$L = \frac{X_L}{2\pi f} = \frac{23}{2\pi \times 50} = 0.073\,H.$ ⟶ [1 M]

(iii) power absorbed = Zero.

$V_m = 230 \times \sqrt{2} = 352.27\,V$ ⟶ [1 M]

3] current through the coil $= I = \frac{V}{R}$

$= \frac{240}{474} = 0.506\,A$

Mean length of magnetic circuit

$l = \pi(25 \times 10^{-2}) = 0.7854\,m.$

magnetizing force $= H = \frac{NI}{l} = \frac{500 \times 0.506}{0.7854}$

$= 322.13\,AT/m.$

Flux density $= B = \mu_0 \mu_r H$

$= 4\pi \times 10^{-7} \times 250 \times 322.13$

$= 0.1012\,wb/m^2$

∴ Flux in air gap = $\phi = B \times a$.

$= (0.1012 \times 40 \times 10^{-6})$

$= \underline{4.0898 \times 10^{-6} \text{ Wb}}$

4]

A) Equivalent resistance & reactance referred to primary

$$R = r_1 + r_2' = r_1 + a^2 r_2$$

$$x = x_1 + x_2' = x_1 + a^2 x_2$$

$a = 10$.

$R = 8\,\Omega + 10^2(0.009) = \underline{8.9\,\Omega}$

$X = 3.2 + a\,10^2(0.03) = \underline{6.2\,\Omega}$

↳ [2 MARKS]

(b) Equivalent resistance and reactance referred to secondary

$$R = \frac{r_1'}{a^2} + r_2 = \frac{8}{10^2} + 0.009 = \underline{0.089\,\Omega}$$

$$X = \frac{x_1'}{a^2} + x_2 = \frac{3.2}{10^2} + 0.03 = \underline{0.062\,\Omega}$$

↳ [2 MARKS]

4] Input $= \sqrt{3} \times 415 \times 80 \times 0.75 \times 10^{-3}$

$= 43.12$ KW

Shaft output $= 43.12 \times 0.75$

$= 32.34$ KW

$N_s = 1500$ rpm. ⟶ (2 MARKS)

$n = (1 - 0.03) \times 1500$

$= 1455$ rpm. $\quad \omega = \frac{2\pi \times 1455}{60} = 152.4$

Shaft torque $= \frac{32.34 \times 1000}{152.36}$

$= 212.26$ N-m ⟶ (2 MARKS)

5] At no load

$I_L = 2$ A

$I_f = 0.9$ A

$I_a = 2 - 0.9 = 1.1$ A.

$E_a = 230 - 1.1 \times 0.8$

$= 229.12$ V

$$229.12 = \frac{6.2 \times 10^{-3} \times n \times 238}{60} \times \frac{6}{2}$$

$$n = 3105.4 \longrightarrow [2M]$$

At load

$$T = 35 \text{ N-m}$$

$$T = \frac{1}{2\pi} \phi I_a Z \frac{P}{A}$$

$$35 = \frac{1}{2\pi} \times 6.2 \times 10^{-3} \times I_a \times 238 \times 3$$

$$I_a = 49.6 \text{ A}$$

$$I_L = 49.6 + 0.9 = 50.57 \text{ A}$$

$$E_a = 230 - 0.8 \times 49.6$$

$$= 190.32 \text{ V}$$

$$192.32 = \frac{6.2 \times 10^{-3} \times n \times 238 \times 3}{60}$$

$$= 2606 \text{ rpm} \longrightarrow [2M]$$

7)

$f_2 = Sf$ ~~=~~ $S = 4\%$.

$n_s = \frac{120 \times f}{P} = \frac{120 \times 50}{4} = 1500$ rpm

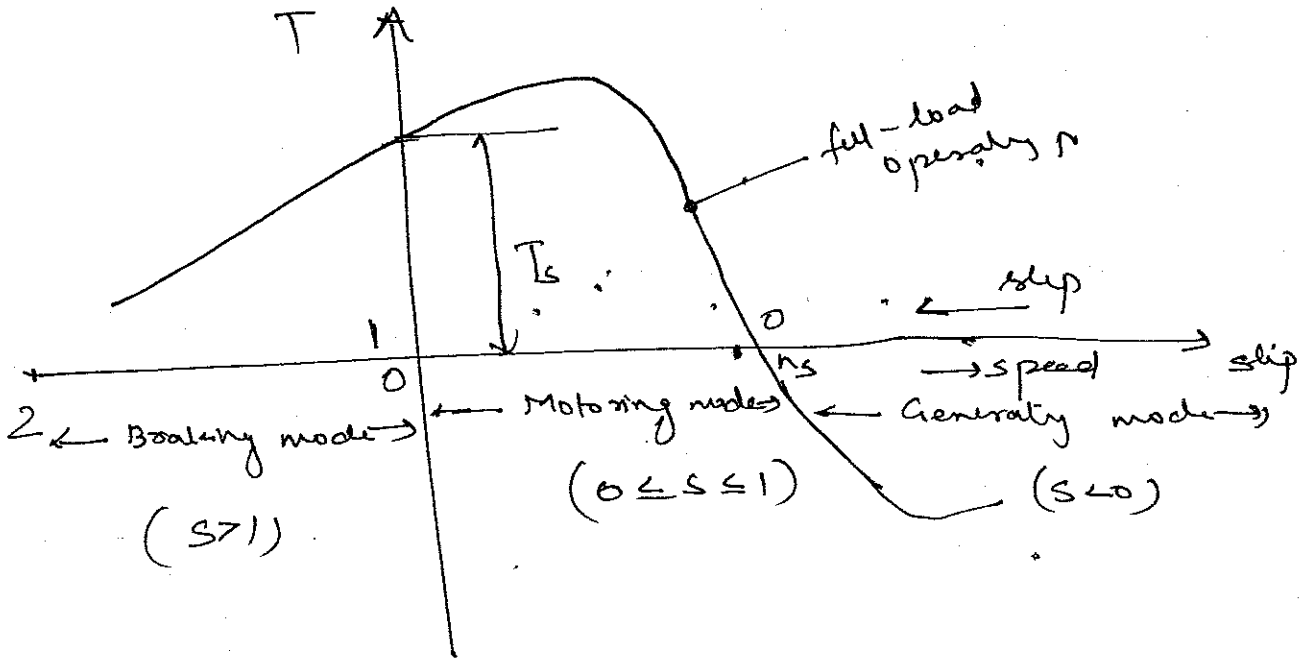
$n = (1 - 0.04) \times 1500 = \underline{1440 \text{ rpm}}$

↳ [1M]

$f_2 = Sf$

$= \frac{4}{100} \times 50 = \underline{2 \text{Hz}}$ → [1M].

8]



↳ 4 [marks]

9]

$$I_a = \frac{45 \times 1000}{\sqrt{3} \times 440} = 59\ A.$$

$pf = 0.8$ Lagging

$I_a = 59 \angle 36.9^\circ\ A.$

$$V_t = \frac{440}{\sqrt{3}} \angle 0 = 254 \angle 0^\circ\ V.$$

$$E_f = 254 \angle 0^\circ - 59 \angle 36.9^\circ \times (0.2 + j2.52).$$

$E_f \approx 320V$

$$I_f = \frac{320}{85} = 3.76\ A \longrightarrow (2M)$$

Electrical power input to motor = $45 \times 0.8 = 36\ kW.$

Field loss $= (3.76)^2 \times 0.35 = 0.494\ kW.$

Total power input = 36.494 kW.

Stator copper loss $= 3 \times (59)^2 \times 0.2$

$= 2.088\ kW.$

Shaft power developed = $36 - 2.088$

$= 33.912\ kW$

$\hookrightarrow [2M]$

10] Core length = $2[(16-4)+(30-4)] - 0.4$.

$= 75.6$ cms

Area of cross section $A_c = 16 cm^2$

Core Reluctance $R_c = \frac{75.6 \times 10^{-2}}{4000 \times 4\pi \times 10^{-7} \times 16 \times 10^{-4}}$.

$= 94 \times 10^{+3}$ AT/wb.

Air gap length = 0.4 cms.

$A_g = 16 cm^2$

Airgap Reluctance $= \frac{0.4 \times 10^{-2}}{4\pi \times 10^{-7} \times 16 \times 10^{-4}}$.

$= 1.98 \times 10^{6}$ AT/wb

R total $= 2.08 \times 10^{6}$ AT/wb. ——→ (2 MARKS)

Flux in magnetic circuit $= \phi = BA$.

$= 1.2 \times 16 \times 10^{-4} = 1.92$ mwb.

$\mathcal{F} = \phi R = Ni$

$= 1.92 \times 10^{-3} \times 2.08 \times 10^{6}$.

$= 4000$ AT.

$i = \frac{4000}{400} = 10$ A ——→ (2 MARKS)

11) Refer doc

(i) conditions for synchronization to main have to be mentioned — [2 MARK]

(ii) Circuit diagram and labelling — [3 MARKS]

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SECOND SEMESTER 2012 – 2013
ES C272 ELECTRICAL SCIENCES II
TEST 2(OPEN BOOK)

MAXIMUM MARKS: 20 **WEIGHTAGE: 20%**
DATE: 24/04/13 **DURATION: 50 MINUTES**

1. The magnetic circuit shown in Figure 1 has a iron core with dimensions shown.A flux of 0.5 wb is required to be established in the air gap of the left central limb.Determine the mmf of the exciting coil, if the core material $\mu_r=\infty$.Neglect fringing

[8 marks]

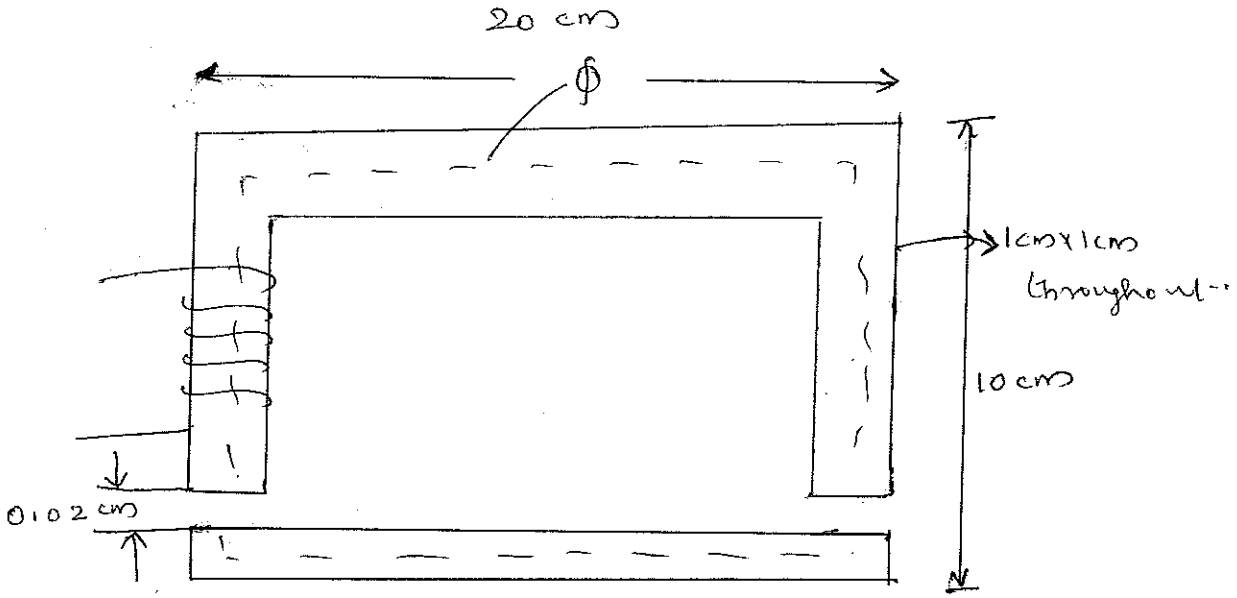


Figure 1

2)An 8 kVA, 400/120 V, 50 Hz, single phase transformer gave the following test results:

OC test: (on LV side): 120V, 4A, 75W
SC test: (on HV side): 9.5 V, 20 A, 110 W

1. a) Draw the circuit model of the transformer with reference to HV side.
1. b) Draw the circuit model of the transformer with reference to LV side.
1. c) Determine the load power factor for zero voltage regulation when the transformer is fully loaded.

[8 marks]

3. A shunt generator delivers50kWat 250V and 400rpm.The armature and field resistances are 0.02 Ω and 50Ω respectively. Calculate the speed of the machine running as shunt motor and taking 50Kw input at 250 V.

[4 marks]

ES C272 ELECTRICAL SCIENCES-II 24/4/13

Test-2 (open Book)

1) Reluctance of air-gap $R_{g_1} = \frac{l_g}{\mu_0 \times 1 \times 1 \times 10^{-4}}$

$= \frac{0.02 \times 10^{-2}}{4\pi \times 10^{-7} \times 10^{-4}} = 1.59 \times 10^6$ AT/wb.

$R_{g_2} = 1.59 \times 10^6$ AT/wb.

Reluctance of R_c core $= \frac{18 + 8 \rightarrow (0.02 \times 2)}{\mu_0 \mu_r \times 1 \times 1 \times 10^{-4}}$

$= \frac{25.96 \times 10^{-2} \times 10^{11}}{4\pi \times 10^{7}} = 2.06 \times 10^9$ AT/wb

$f = \phi (R_{g_1} + R_{g_2} + R_c)$.

$= 0.5 (1.59 \times 10^6 \times 2 + 2.06 \times 10^9)$

$= 2.07 \times 10^6$ AT

2) OC on the LV side $Y_0 = \frac{4}{120} = 0.033$ ℧

$G_i = \frac{75}{(120)^2} = 5.2 \times 10^{-3}$ ℧.

$B_m = \sqrt{(0.033^2 - (5.2 \times 10^{-3})^2)}$

$= 0.032$ ℧

SC on HV side

$$Z = \frac{9.5}{20} = 0.475\ \Omega$$

$$R = \frac{110}{(20)^2} = 0.275\ \Omega$$

$$X = \sqrt{0.475^2 - 0.275^2} = 0.387\ \Omega$$

(a) circuit model referred to HV side

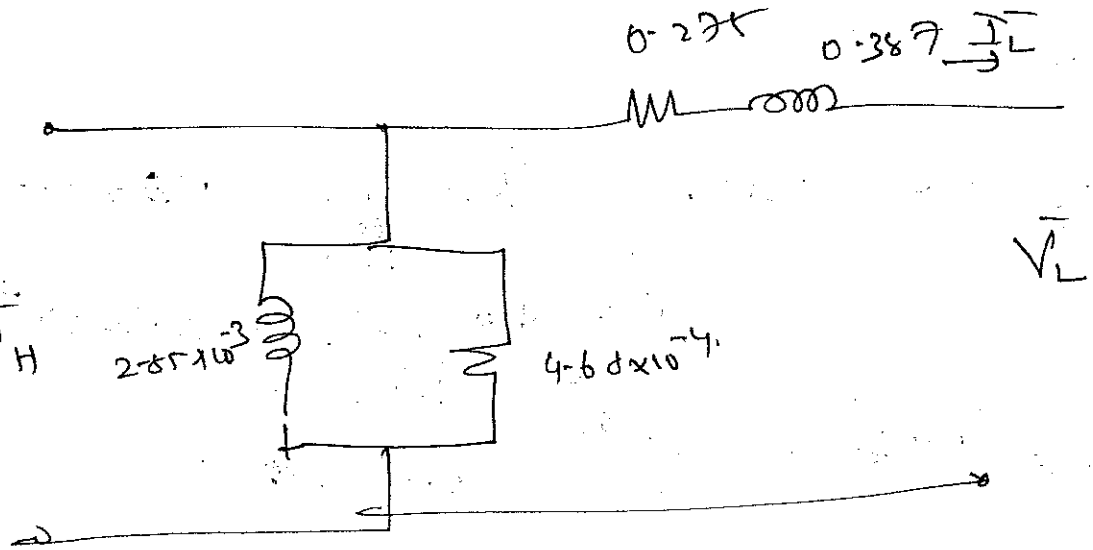
$$a = \frac{400}{120} = 3.33$$

$$G_i = 5.2\times10^{-3} \times \frac{1}{(3.33)^2} = 4.68\times10^{-4}$$

$$B_m = 0.032 \times \frac{1}{3.33^2} = 2.85\times10^{-3}$$

$R = 0.275\ \Omega$

$X = 0.387\ \Omega$.



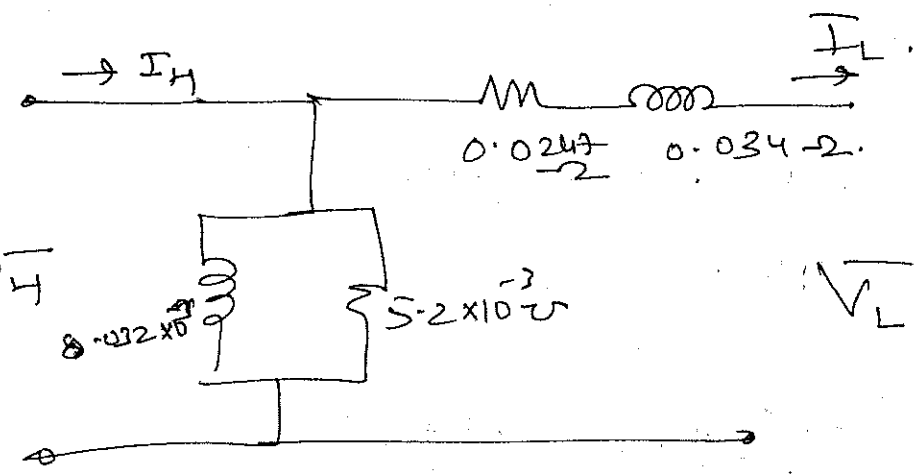
(b) Circuit model referred to LV side.

$G_i = 5.2 \times 10^{-3}$ ℧

$B_m = 0.032$ ℧.

$$R = 0.275 \times \frac{1}{(3.33)^2} = 0.0247\ \Omega$$

$$X = 0.387 \times \frac{1}{3.33^2} = 0.034\ \Omega.$$



(c) $pf = \cos\theta = \dfrac{R}{[R^2 + X^2]^{1/2}}$

$$= \frac{0.387}{(0.275^2 + 0.387^2)^{1/2}}$$

$\cos\theta = 0.81$

3] As generator

$$I_a = \frac{50 \times 10^3}{250} = 200\ A.$$

$$E_{ag} = 250 + 0.02 \times 200$$

$$= \underline{254}\ V.$$

2 As a motor:

$$E_{am} = 250 - 0.02 \times 200$$

$$= 246.$$

(3).

$$\frac{254}{246} = \frac{\phi_g}{\phi_m} \frac{\left(\frac{2 \times 400}{60}\right)}{\frac{2 \times N}{60}}$$

$$\frac{254}{246} = \frac{400}{N}.$$

$$N = \frac{400 \times 246}{254} = \underline{387\ rpm}$$

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ES C272 ELECTRICAL SCIENCES II
TEST 1(CLOSED BOOK)

MAXIMUM MARKS: 25 **WEIGHTAGE: 12%**
DATE: 27/03/13 **DURATION: 50 MINUTES**

1. Two circuits with impedances Z1= 25+j10 Ω and Z2= 120+j250 Ω respectively are connected in parallel. If the total current applied is 25 A, find each branch current and their phase angle with the total current. Also find the total applied voltage.

[8 marks]

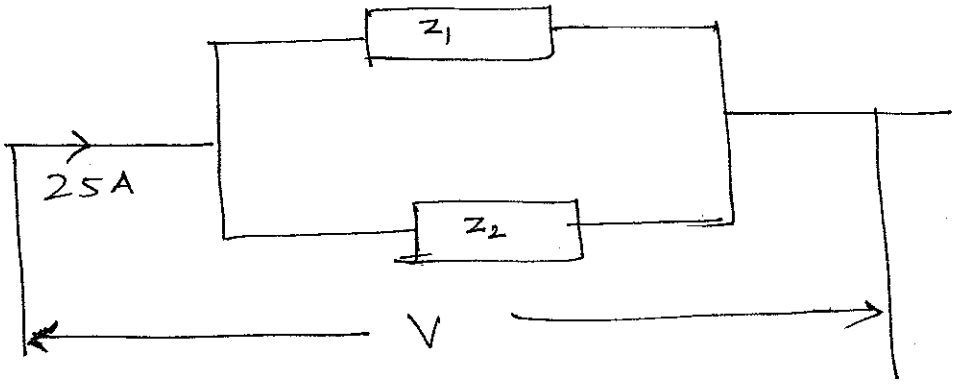

Figure 1

2. For the series RLC circuit shown in Figure 2, Find
   a) Frequency in Hertz.
   b) Inductive and Capacitive reactance.
   c) Driving point impedance and admittance.
   d) Phasor voltage and current.
   e) Real and Reactive power supplied by the source. **[8 marks]**

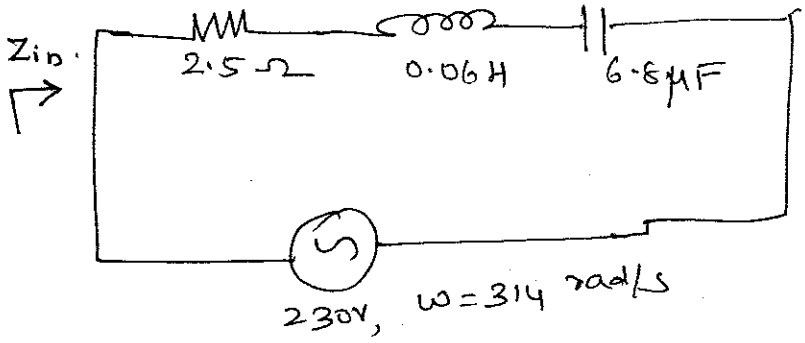

Figure 2

3. A 20KVA load at 0.8 power factor lagging is fed from 220 Volts, 50Hz, single phase supply. Calculate the KVA capacity and the capacitance value of the shunt capacitor required to improve the overall power factor (load + shunt capacitor) to 0.92 lagging. Compare the current drawn from the supply before and after installing the capacitor. **[9 marks]**

Test -1 · (Closed Book) 27/3/13.

1) $\underline{I} = 25\angle 0$ A.

$$\underline{I_1} = 25\angle 0 \times \frac{120+j250}{(25+j10+120+j250)}$$

$$= \frac{120.41\angle 4.76}{(145+j260)}$$

$$= \frac{120.41\angle 4.76}{297.69\angle 60.85} \times 25$$

$$= 10.11\angle -56.09$$

$$\underline{I_2} = 25\angle 0 \times \frac{25+j10}{297.69\angle 60.85}$$

$$= 2.19\angle -39.05$$

$$V = 10.11\angle -56.09 \times 26.12\angle 21.8$$

$$= 264.07\angle -34.29 \text{ V}$$

2) (a) $f = \frac{\omega}{2\pi} = \underline{50Hz}$

(b) $X_L = 2\pi f L = 100\pi \times 0.06H$

$= \underline{18.85\Omega}$

$X_c = \frac{1}{2\pi f c} = \frac{1}{100\pi \times 6.5 \times 10^{-6}} = 468\ \Omega$

(C)

$Z_{in} = R + j(X_L - X_c)$

$= 2.5 + j(18.85 - 468)$

$= 2.5 - j(486.85)$

$= \underline{486.85 \angle -89.7\ \Omega}$

$Y_{in} = \frac{1}{486.85 \angle -89.7} = \underline{2.05 \times 10^{-3} \angle 89.7\ \mho}$

3) $P_L + jQ_L = 20 \times 0.8 + j\,20 \times \sin\cos^{-1} 0.8$

$= 16 + j12$

(a) $P_s + jQ_s = 16 + j(12 - Q_c)$

New $Pf = \cos \tan^{-1} \frac{12 - Q_c}{16} = 0.92$

$$12 - Q_c = 6.81$$

$$-Q_c = 6.81 - 12$$

$$Q_c = 5.18 \text{ kVAr.}$$

$$5.18 = \frac{(220)^2 \times 314 \times C}{1000}$$

$$C = 3.4 \times 10^{-4} \text{ F.}$$

$$20 = \frac{220 \times I_S}{1000}$$

$$= \underline{90.9 \text{ A}}$$

After

$$16 + j(12 - 5.16) = 16 + j\,6.84$$

$$= 17.39 \angle 23.08^\circ$$

$$I_S = \frac{17.39 \times 1000}{220} = \underline{79.04 \text{ A}}$$

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ES C272 ELECTRICAL SCIENCES II
QUIZ 2 (CLOSED BOOK)

MAXIMUM MARKS: 7 | SET 1 | WEIGHTAGE: 7 %
DATE: 13.05.13 | DURATION: 20 MINUTES

NAME: Id. No.:

1. The polar form of phasor is used for

(A) Addition only. (B)For addition and subtraction.
(C) Multiplication only (D)Division and Multiplication.

[1 Marks]

2. Magnetic cores should have

(A) Large permeability. (B) Small permeability.
(C) Zero permeability. (D) none of the above.

[1 Marks]

3. The ideal value of regulation in a transformer should be _____. [1 Marks]

4. A ring of magnetic material has rectangular cross section. The inner diameter of the ring is 20cm and the outer diameter is 30 cm, its thickness being 4cm. The mean flux path length is _____ [2 Marks]

5. The phasor form of resistance is _____ [1Mark]

(A) R∟0.
(B) R∟30..
(C) R∟90..
(D) none of the above.

6. The unit of magnetic Flux density is _____ [1Mark]

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QUIZ 2 (CLOSED BOOK)

MAXIMUM MARKS: 7 | SET 1 | WEIGHTAGE: 7 %
DATE: 13.05.13 | DURATION: 20 MINUTES

NAME:	Id. No.:

1. The polar form of phasor is used for

(A) Addition only. (B)For addition and subtraction.
(C) Multiplication only (D)Division and Multiplication. [1 Marks]

2. Magnetic cores should have

(A) Large permeability. (B) Small permeability.
(C) Zero permeability. (D) none of the above. [1 Marks]

3. The ideal value of regulation in a transformer should be 0. [1 Marks]

4. A ring of magnetic material has rectangular cross section. The inner diameter of the ring is 20cm and the outer diameter is 30 cm, its thickness being 4cm. The mean flux path length is 78.53 cm [2 Marks]

5. The phasor form of resistance is _____ [1Mark]

(A) R∟0.
(B) R∟30..
(C) R∟90..
(D) none of the above.

6. The unit of magnetic Flux density is wb/m^2 [1Mark]

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ES C272 ELECTRICAL SCIENCES II
QUIZ 1 (CLOSED BOOK)

MAXIMUM MARKS: 8 WEIGHTAGE: 8 %
DATE: 27.02.13 DURATION: 20 MINUTES

NAME: Id. No.:

1. For an ac circuit containing inductance only the real power consumed by the circuit is _____. [1 Marks]

2. The reactance of a capacitor at 50 hz is 5 ohms.If the frequency is increased to 100 hz , the new reactance is _____ [1 Marks]

3. To improve the power factor of the power system network _____ are installed. [1Mark]

4. In a parallel circuit with R=10 Ω, X_L = 50 Ω, X_C = 10 Ω and carrying an effective current of 10A, the real power dissipated P = _____ and reactive power Q = _____ [2Marks]

5. The phasor 20∟10 in rectangular form is _____ [1Mark]

6. Two electric bulbs rated at P1 watts, V volt and P2 watts V volts are connected in series across V volts. The total power consumed is_____ [2Marks]

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SECOND SEMESTER 2012 – 2013
ES C272 ELECTRICAL SCIENCES II
QUIZ 1 (CLOSED BOOK)

MAXIMUM MARKS: 8 | WEIGHTAGE: 8 %
DATE: 27.02.13 | DURATION: 20 MINUTES

NAME: Id. No.:

1. For an ac circuit containing inductance only the real power consumed by the circuit is 0. [1 Marks]

2. The reactance of a capacitor at 50 hz is 5 ohms.If the frequency is increased to 100 hz , the new reactance is 10 Ω [1 Marks]

3. To improve the power factor of the power system network capacitors are installed. [1Mark]

4. In a parallel circuit with R=10 Ω, X_L = 50 Ω, X_C = 10 Ω and carrying an effective current of 10A, the real power dissipated P = 1 kW and reactive power Q = 4 kVAR [2Marks]

5. The phasor 20∠10 in rectangular form is $19.69 + j3.47$ [1Mark]

6. Two electric bulbs rated at P1 watts, V volt and P2 watts V volts are connected in series across V volts. The total power consumed is $P_1 + P_2$ [2Marks]