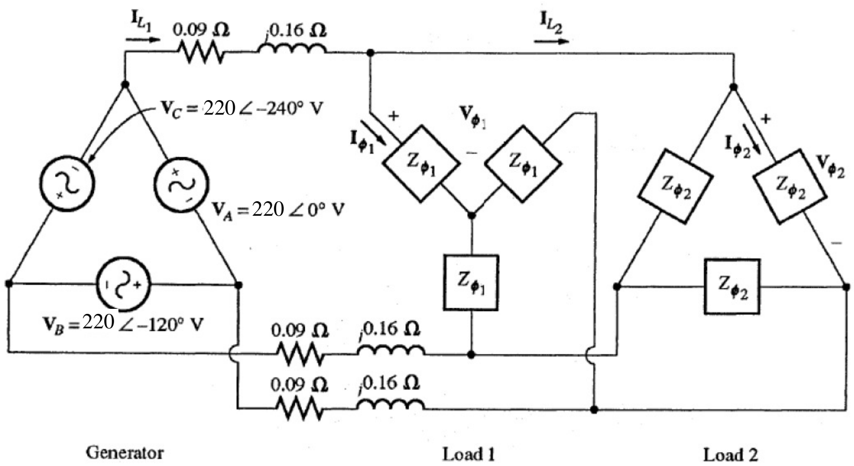
Concordia UNIVERSITY

COURSE : Electrical power engineering	NUMBER: ELEC 331	SECTION: W			
EXAMINATION : Midterm	DATE : 24-02-14	TIME : 13:15 - 14:30	# OF PAGES: 2		
INSTRUCTOR: Luiz Lopes					
SPECIAL INSTRUCTIONS:	- Answer all questions. No crib sheets. In cascaded questions, you can assume suitable values for parameters you are not able to calculate in previous sub-questions.				

1) A 220 V / 60 Hz three-phase Δ-connected generator supplies two loads. Load 1 presents an impedance of 2.5 $\angle$-36.87 Ω while Load 2 consists of a resistance of 3 Ω in series with an inductance of 4 mH. Compute:

a. The rms value of the line voltage across the loads
b. The (three-phase) reactive power consumed by Load 1.
c. The rms value of the phase current in Load 2 ($I_{\phi 2}$).

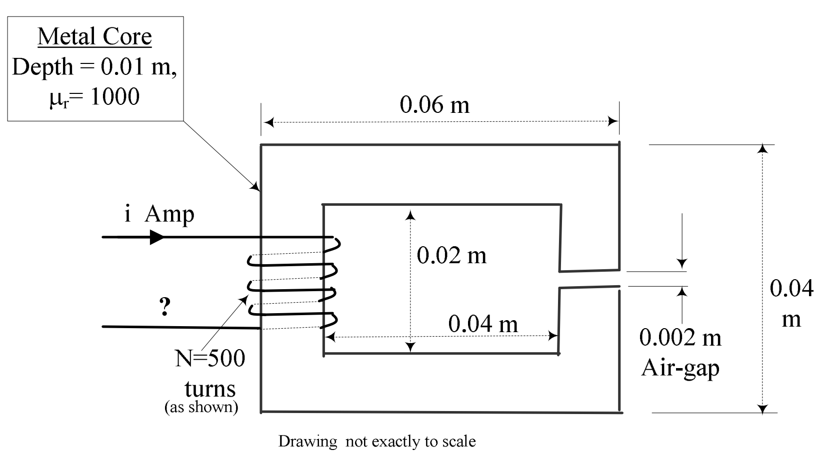
(30 marks)



2) Consider the magnetic structure shown below. The DC current (i) is equal to 8 A.

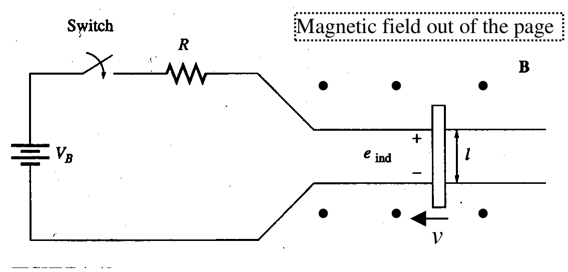
a. Draw the analogous magnetic circuit, clearly showing the MMF, and its value, the flux (direction) and the reluctance(s).
b. Determine the flux density (B) in the (metal) core. Neglect the fringing effect of the air-gap. (ELEC-275 final 2012)

(20 marks)



3) The linear DC machine shown below presents the following parameters: V_B = 100 V, R = 0.2 Ω, l = 5 m and B = 0.5 T. Consider the steady-state condition when the switch is closed and the bar is moving with a speed of 32 m/s. Compute:

a. The power supplied by the battery to the DC machine
b. The required external force (magnitude and direction, i.e. right-to-left or left-to-right) on the bar for this operating condition.

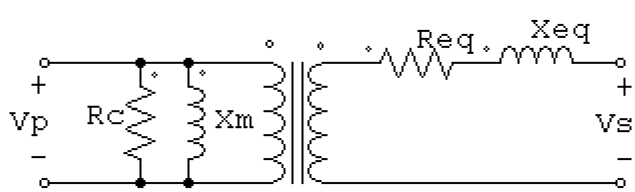


(20 marks)

4) A 75 kVA 14.4 kV:240 V single-phase transformer has the following parameters: R_{eq} = 7.68 mΩ and X_{eq} = 38.4 mΩ, seen from the low voltage side and R_c = 100 kΩ and X_M = 250 kΩ, seen from the high voltage side.

a. Draw the per-unit equivalent model showing all impedances and their magnitudes.
b. Using the pu equivalent model, compute the voltage regulation of the transformer when supplying 75 kVA to a resistive inductive load with power factor of 0.85 and at rated (load) voltage.
c. How much power could this transformer supply to a load if connected as a step-up auto-transformer?

(30 marks)



Formula sheet

Ac circuits:

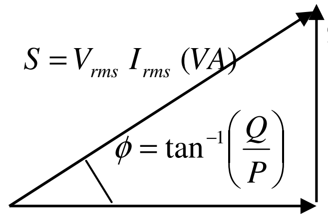
$\bar{S} = \bar{V}\,\bar{I}^* = P + j\,Q = |\bar{V}||\bar{I}|(\cos\phi + j\sin\phi)$

$S = \sqrt{P^2 + Q^2}$ $\qquad PF = P/S = \cos\phi$

$P_{3\phi} = \sqrt{3}\,V_L I_L \cos\theta = 3\,I_L^2\,Z\cos\theta$

$Q_{3\phi} = \sqrt{3}\,V_L I_L \sin\theta = 3\,I_L^2\,Z\sin\theta$

$S_{3\phi} = \sqrt{3}\,V_L I_L = 3\,I_L^2\,Z$



$S = V_{rms}\,I_{rms}\ (VA)$

$Q = V_{rms}\,I_{rms}\sin\phi\ \ (VAr)$

$\phi = \tan^{-1}\left(\dfrac{Q}{P}\right)$

$P = V_{rms}\,I_{rms}\cos\phi\ \ (W)$

$Z_Y = Z_\Delta / 3$

System with multiple elements

$\bar{S}_T = \bar{S}_1 + \bar{S}_2$ (complex power!), $Q_T = Q_{L1} + Q_{L2}$, $P_T = P_{L1} + P_{L2}$

$Q_{Cap} = -\dfrac{V^2}{X_C} = -V^2\omega C$

Magnetic Circuits:

$\oint H \bullet dl = I_{net},\ H\,l_c = N\,i,\ H = \dfrac{N\,i}{l_c}$ (Ampere - turn/m) $\qquad B = \mu\,H,\ \ \mu = \mu_r\,\mu_0,\ \ \mu_0 = 4\pi \text{ x}10^{-7}$ H/m

$\phi = \int_A B \bullet dA,\ \ \phi = BA, \phi = \dfrac{\mu\,N\,i\,A}{l_c}$ (Weber – Wb) $\qquad \Im = N\,i,\ \ \Im = \phi\,\Re,\ \ \Re = \dfrac{\Im}{\phi} = \dfrac{l_c}{\mu\,A}$ $\qquad e_{ind} = N\dfrac{d\phi}{dt}$

$e_{ind} = (v \times B) \bullet l \qquad F = i(l \times B)$

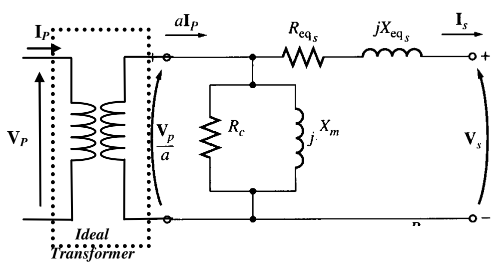
Transformers:

(ideal) $\quad \dfrac{v_P(t)}{v_S(t)} = \dfrac{N_P}{N_S} = a,\ \ \dfrac{i_P(t)}{i_S(t)} = \dfrac{N_S}{N_P} = \dfrac{1}{a}$

$P_{in} = P_{out}, Q_{in} = Q_{out}, S_{in} = S_{out},\ Z_{in} = a^2 Z_L$

$Y_E = \dfrac{1}{R_C} - j\dfrac{1}{X_M} = |Y_E|\angle -\theta_{OC},\ \ |Y_E| = \dfrac{I_{OC}}{V_{OC}},\ \cos\theta_{OC} = \dfrac{P_{OC}}{I_{OC}\,V_{OC}}$

$Z_{SE} = R_{eq} + jX_{eq} = |Z_{SE}|\angle\theta_{SC},\ \ |Z_{SE}| = \dfrac{V_{SC}}{I_{SC}},\ \cos\theta_{SC} = \dfrac{P_{SC}}{I_{SC}\,V_{SC}}$



Approximate equivalent Transformer Model

$VR = \dfrac{V_{S,nl} - V_{S,fl}}{V_{S,fl}}\,x100\% \qquad \eta = \dfrac{P_{out}}{P_{in}}\,x100\% = \dfrac{P_{out}}{P_{out} + P_{core} + P_{Cu}}\,x100\%, \qquad P_{Cu} = I_S{}^2 R_{eq}, \qquad P_{core} = \dfrac{(V_p / a)^2}{R_C}$

$v(t) = V_M \sin\omega t \qquad \phi(t) = \dfrac{1}{N_p}\int v(t)\,dt \qquad \phi(t) = -\dfrac{V_M}{\omega N_p}\cos\omega t \qquad \hat{\phi}_{ss} = -\dfrac{V_M}{\omega N_p}$

autotransformers: $\dfrac{V_C}{V_{SE}} = \dfrac{N_C}{N_{SE}} \qquad N_C I_C = N_{SE} I_{SE} \qquad \dfrac{V_L}{V_H} = \dfrac{N_C}{N_{SE} + N_C} \qquad \dfrac{I_L}{I_H} = \dfrac{N_{SE} + N_C}{N_C} \qquad \dfrac{S_{IO}}{S_{Wind}} = \dfrac{N_{SE} + N_C}{N_{SE}}$

pu system: $\qquad \text{Quantity (pu)} = \dfrac{\text{Actual Value}}{\text{Base value of quantity}}$