PhD Preliminary Exam

Electrical and Computer Engineering Dept.

Prairie View A&M University

Fall 2017

Power Questions

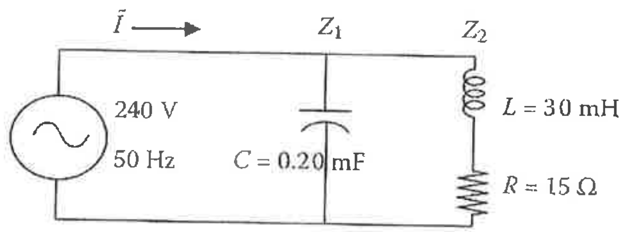
Student Name____

Date______________________________

Score___________ (100 scale)

(20)

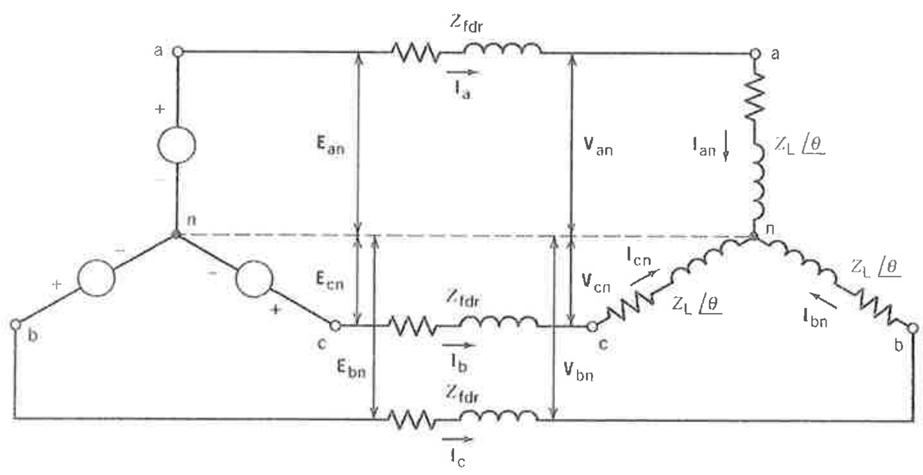
#1. A 240 V, 50 Hz. Single phase voltage is applied to the circuit shown in the following figure. Determine the current, pf, and power delivered by the source. L = 30 milliHenry, C = 0.20 milliFarad.



1 CONTINUED

(20)

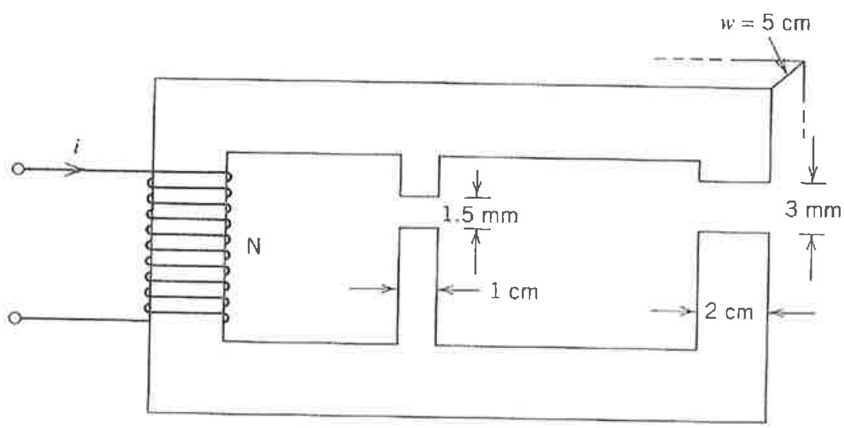
#2 A three-phase power system consists of a wye-connected ideal generator connected to a wye-connected load through a three-phase feeder. The load has an impedance of $Z_L = 20\angle 30^\circ$ ohm/phase, and the feeder has an impedance $Z_{fdr} = 1.5\angle 75^\circ$ ohm/phase. The terminal voltage of the load is $V_{LL} = 4.16$ kV. Determine (a) the terminal voltage of the generator and (b) the line current supplied by the generator.



(a)

#2 CONTINUED

(20) #3. An electromagnetic with two air gaps is shown below. The relative permeability of the iron is assumed to be infinite, and flux fringing in the air gaps can be neglected. The coil has 500 turns, and is supplied with a current of 2.5 amps. Find the value of the magnetic flux in each air gap. $\mu = 4\pi \times 10^{-7}$ for free space

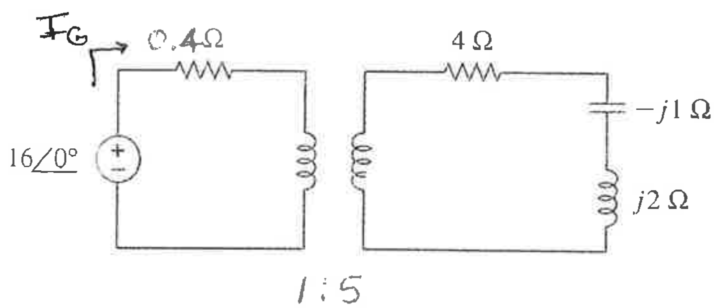


#3 CONTINUED

#4. The following is a single phase power system with sending end generator of $16\angle 0^\circ$ volts, transformer with voltage ratio of 1:5. It has receiving end impedances of 4 ohms, -j1 ohm and j2 ohms.

(10) 1) Determine the value of the generator current I_G by referring all circuit parameters to the primary side of the transformer.

(10) 2) Determine the value of the generator current I_G by changing all values to per unit values and then calculating the current with the unified circuit. You should choose your base values, but the base voltage should be 16-V on the primary side.



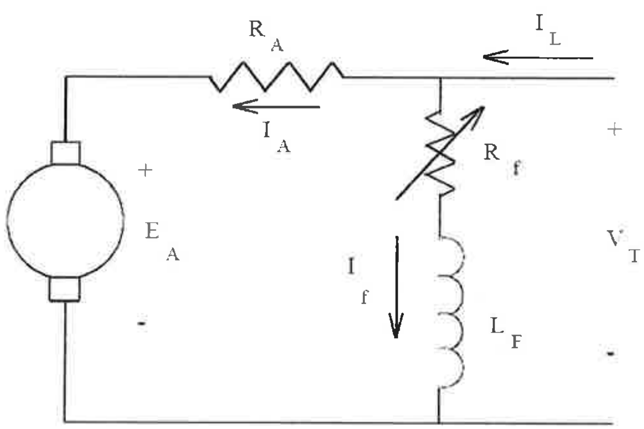
#4 CONTINUED

#5. A 230V, shunt excited DC motor has R_A =0.05 Ω and R_f =75 Ω. The motor draws a line current, I_L, of 7 Amps when lightly loaded and turning at 1120 RPM. With the machine loaded such that the line current is 46 Amps, answer the following. Assume the iron is linear (i.e. no saturation in EA vs. I_f curve). Rev = 2 πrad R_a = 0.05ohm R_f = 75ohm n_1 = 1120 rev /min I_L = 7A, V_t = 230V, I_{new} = 46Amps

(10) a) Find speed in RPM

(5) b) Find induced Torque

(5) c) Suppose the field resistance is changed to 100Ω, find first the new field current and then find the speed if the line current stays at 46 Amps.



#5 CONTINUED

$$e_{ind} = (v \times B) \cdot l$$
$$= vBl \sin\theta$$

$V = r\omega$ = velocity tangential
B = flux density
l = length of wire
$\theta = \omega t$ = angle between B field and velocity (V)

$$\text{Torque} = \tau = (\text{force applied})(\text{perpendicular distance})$$
$$= (F)(r \sin\theta)$$
$$= r\omega B l \sin\theta$$

$$F = i(l \times B)$$

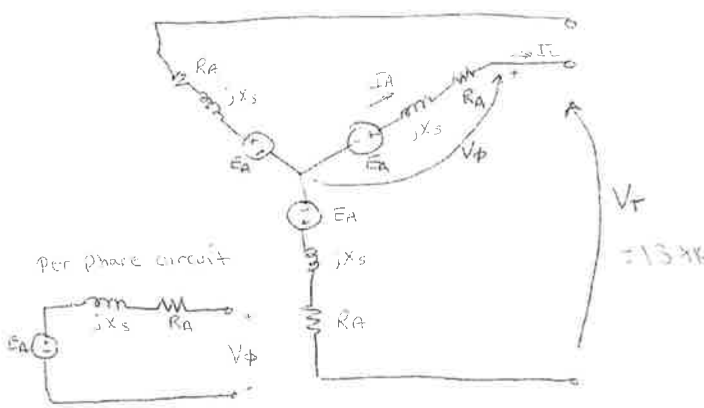
$$B = \frac{\mu N i}{l_c}$$

l_c in this case is length of loop
μ = permeability
$\mu_o = 4\pi \times 10^{-7}$ H/m
μ_r = relative permeability
$\mu = \mu_r \mu_o$
i = three phase current

VI.

For generator
$V_\phi = E_A - jX_s I_A - R_A I_A$

Y connection $I_\phi = I_{line}$
$I_A = I_{line}$
$I_\phi = I_L$
$V_L = \sqrt{3} V_\phi$



Y connected generator
V_ϕ = phase voltage
" terminal voltage

For three phase power
$P = 3V_\Phi I_\Phi \cos\theta$
Or
$P = \sqrt{3}\, V_{LL} I_L \cos\theta$
PF = $\cos\theta$

FORMULAS   ELEG 4013

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

- Reluctance ($\mathcal{R}$)

  $\mathcal{R} = \frac{l}{\mu \mu_0 A}$ $\frac{\text{mean path length}}{\text{relative} \times \text{free space permeability} \times \text{cross sectional area}}$

- Flux density (B)

  $B = \mu H = \frac{\mu N i}{l_c}$ where $H = \frac{N i}{l_c}$ $\frac{\text{turns} \times \text{current}}{\text{mean path length}}$

- Flux (ϕ)

  length units are in meters

  $\phi = BA$ flux density times area

- magnetomotive force ($\mathcal{F}$)

  $\mathcal{F} = Ni$ turns time current

- also flux equals

  $\phi = \frac{\mathcal{F}}{\mathcal{R}}$ $\frac{\text{Magnetomotive Force}}{\text{Reluctance}}$ Reluctances combine like resistors

- Induced force on a wire

  $\vec{F} = i(\vec{l} \times \vec{B})$ direction of $\vec{l}$ is direction of current

- Induced voltage on a conductor

  $e_{ind} = (\vec{v} \times \vec{B}) \cdot \vec{l}$ velocity cross with B field this result dotted with l (length of conductor)

- For three phase Y connection

  $V_{LL} = \sqrt{3} V_\phi$ Line voltage is $\sqrt{3}$ times phase voltage

  $I_{LL} = I_\phi$

- For three phase Δ connection

  $I_{LL} = \sqrt{3} I_\phi$ Line current is $\sqrt{3}$ times phase current

  $V_{LL} = V_\phi$

Table 2–1 | Summary of relationships in Y and Δ connections

	Y connection	Δ connection
Voltage magnitudes	$V_{LL} = \sqrt{3} V_\phi$	$V_{LL} = V_\phi$
Current magnitudes	$I_L = I_\phi$	$I_L = \sqrt{3} I_\phi$
abc phase sequence	V_{ab} leads V_a by 30°	I_a lags I_{ab} by 30°
acb phase sequence	V_{ab} lags V_a by 30°	I_a leads I_{ab} by 30°

Three phase power equations

$P = 3V_\phi I_\phi \cos\theta$

$Q = 3V_\phi I_\phi \sin\theta$

$S = 3V_\phi I_\phi$

$P = 3I_\phi^2 Z \cos\theta$

$Q = 3I_\phi^2 Z \sin\theta$

$S = 3I_\phi^2 Z$

Slip $s = n_{slip}/n_{sync}$ n = slip

$n_m = (1-s)n_{sync}$ n_m = mechanical speed

$n_{sync} = (120 \times f_e)/P$

Transformer Open circuit short circuit model

Core properties

$Y_E = G_c - jB_m$

$|Y_E| = \frac{I_{oc}}{V_{oc}}$ $PF = \cos\theta = \frac{P_{oc}}{V_{oc} I_{oc}}$

$Y_E = \frac{I_{oc}}{V_{oc}} \angle -\theta$

Line properties

$Z_{SE} = R_{eq} + jX_{eq}$

$|Z_{SE}| = \frac{V_{sc}}{I_{sc}}$ $PF = \cos\theta = \frac{}{V}$

$Z_{se} = \frac{V_{sc} \angle 0^\circ}{I_{sc} \angle -\theta^\circ} = \frac{V_{sc}}{I_{sc}} \angle \theta^\circ$

$\text{Quantity per unit} = \frac{\text{actual value}}{\text{base value of quantity}}$

P_{base}, Q_{base}, or $S_{base} = V_{base} I_{base}$

$Z_{base} = \frac{V_{base}}{I_{base}}$ $Y_{base} = \frac{I_{base}}{V_{base}}$

Referred Impedance
from secondary to primary

basic concept $\left\{ a = \frac{N_P}{N_S} = \frac{V_P}{V_S} \right\}$ current the opposite

$Z'_{Load} = a^2 Z_{Load}$ just the opposite for primary to secondary

DC MOTORS

- with constant field flux the following proportion exist

$$\frac{\text{Voltage @ light load}}{\text{Rpm @ light load}} = \frac{\text{Voltage @ increased load}}{\text{Rpm @ increased load}}$$

$$\frac{E_{a1}}{n_1} = \frac{E_{a2}}{n_2}$$

- $\text{Torque} = \tau = \frac{P}{\omega}$

$$\omega = \frac{n_2 \, 2\pi}{60}$$