UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2010/2011

COURSE	:	ELECTRICAL POWER SYSTEM
COURSE CODE	:	BEE 3243
PROGRAMME	:	3 BEE
EXAMINATION DATE	:	APRIL / MAY 2011
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER ALL QUESTIONS

THIS PAPER CONSISTS OF NINE (9) PAGES

Q1 (a) In power system network analysis, it is often involved a single-phase and three-phase equivalent circuit with the parameters are marked in per-unit quantities.

(i) State the purpose of using single-line diagram or one-line diagram in power system network analysis
(ii) Define the per-unit quantity used in power system analysis and list two (2) advantages of using this quantity.

(5 marks)

(b) A symmetrical fault in three-phase power system network is also known as balanced fault. This type of fault can only be appeared when all three lines are in the faulted condition or short circuited. Figure Q1(b) shows a simple impedance diagram on three buses power system network with a fault occurs at bus 2. The bus admittance matrix of the system is determined as;

$$Y_{bus} = \begin{bmatrix} -j6.33 & j1.67 & j1.33 \\ j1.67 & -j8.17 & j2.5 \\ j1.33 & j2.5 & -j3.83 \end{bmatrix}$$

Hence,

(i) Compute the bus impedance matrix, Z_{bus} of the system,
(ii) Determine the faulted current at bus 2 if $Z_f = j0.18$ p.u.
(iii) Find the voltage on each bus during fault and
(iv) Calculate the line current that flowing in each line during fault.

(8 marks)

(c) Unsymmetrical fault is more frequent fault occur in a power system network and the symmetrical components are used in fault analysis study. Figure Q1(c) shows a line to ground fault on phase 'a' through an impedance of Z_f.

(i) Prove that the faulted current for single-line to ground on phase 'a' is

$$I_f = I_a = 3I_a^0 = \frac{3E_a}{Z^1 + Z^2 + 3Z_f}$$

(ii) Propose two (2) activities that can minimize fault happen on power system network.

(12 marks)

Q2 (a) List and explain briefly four (4) types of typical substation system.

(4 marks)

(b) A three-phase 275 kV, 50 Hz, 200 km completely transposed transmission line has the positive-sequence impedance, $z = 0.0345 + j\ 0.4023\ \Omega/\text{km}$ and admittance, $y = j\ 3.88 \times 10^{-6}$ S/km. The receiving-end load consists of 170 MW (active power) and 105.36 MVar (reactive power - inductive) and it is operating at 270 kV. By using nominal-π method (medium line method), find the followings:

(i) Sending-end voltage, V_S.
(ii) Sending-end current, I_S.
(iii) Sending-end power factor, $\cos\theta_S$.
(iv) Voltage regulation for this transmission model.
(v) Efficiency, η of the transmission system.
(vi) Draw the phasor diagram for the transmission system.

(21 marks)

Q3 (a) Power flow study involves numerical analysis applied to power systems.

(i) Give three (3) types of network buses in power flow analysis
(ii) State the two (2) basic problems to be discussed in load flow analysis

(5 marks)

(b) In order to obtain the node-voltage equations, a simple power system diagram shown in Figure Q3(b) where impedances are expressed in per unit on a common MVA base and for simplicity resistances are neglected.
(i) Determine the admittance matrix for the network.
(ii) Calculate new admittance values for Y_{11}, Y_{12}, Y_{24} and Y_{44} by using Kron reduction method when node 3 is removed from the nodal admittance equation matrix.

(10 marks)

(c) Figure Q3(c) shows the one-line diagram of a simple power system with generation at bus 1. The voltage at bus 1 is $V_1 = 1.0\angle 0°$ per unit. Bus 2 is a load bus with S_2= 300 MW + j40Mvar. The line impedance on a base of 100 MVA is Z = 0.05+j0.04 per unit.

(i) Using Gauss-Seidel method and initial estimates of $V_2^{(0)} = 1.0 + j0$, determine V_2 (accurate to four decimal places). Perform two iterations.
(ii) If after several iterations, voltage at bus 2 converge to

$$V_2 = 0.9315 - j0.0655 \text{ pu}$$

Determine the line flows, S_{12} and S_{21} and the real and reactive power loss in the line.

(10 marks)

Q4 (a) To meet the safety, reliability and quality supply from network, the protection scheme must be taken into consideration. This protection scheme is installed to clear and limit any damage to distribution equipment.

(i) Give three major components which are commonly constituted in a power system protection scheme.
(ii) Explain briefly how these three major components work when a fault occur in a system.

(6 marks)

(b) Consider the radial system shown in Figure Q4(b) and find the followings:

(i) Calculate the fault current for fault F_A, F_B and F_C.
(ii) Propose relays setting, R1 and R2 on the basis of current grading, assuming 40% relay error margin.

(8 marks)

(c) Consider a Δ/Y-connected, 30 MVA, 33/11-kV transformer shown in Figure Q4(c) with differential protection applied. The CT ratio at the secondary side is 3000/5 A and at the primary side is X/5 A. The minimum relay current setting is 1.0548 A with 150% overload.

(i) Calculate the relay current during full load.
(ii) Calculate the CT current on the primary side when the current on the secondary side is 4.5454 A.
(iii) Determine the ratio of the CT at primary side.

(11 marks)

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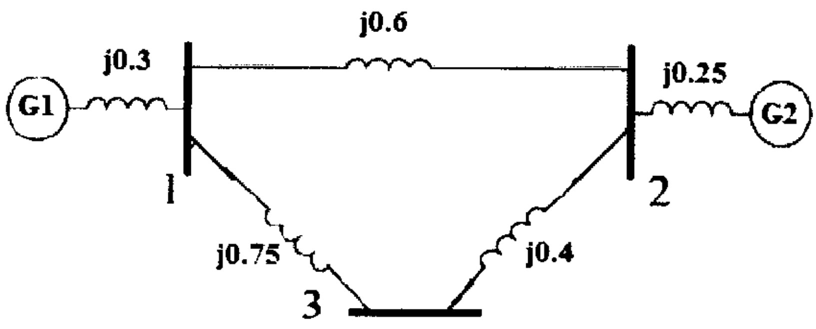

Figure Q1(b)

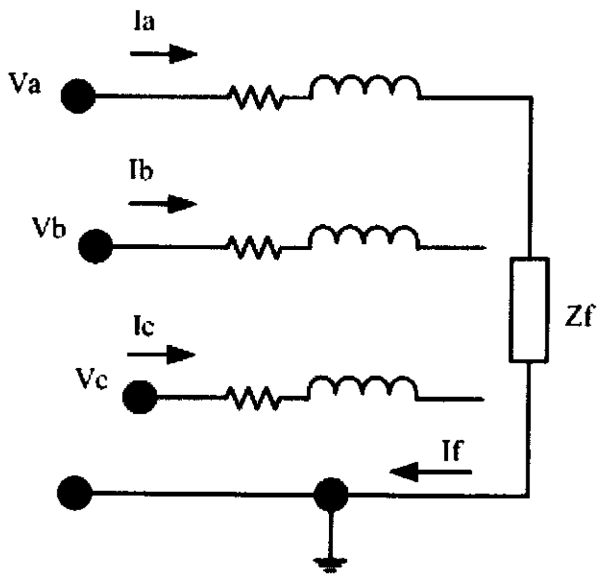

Figure Q1(c)

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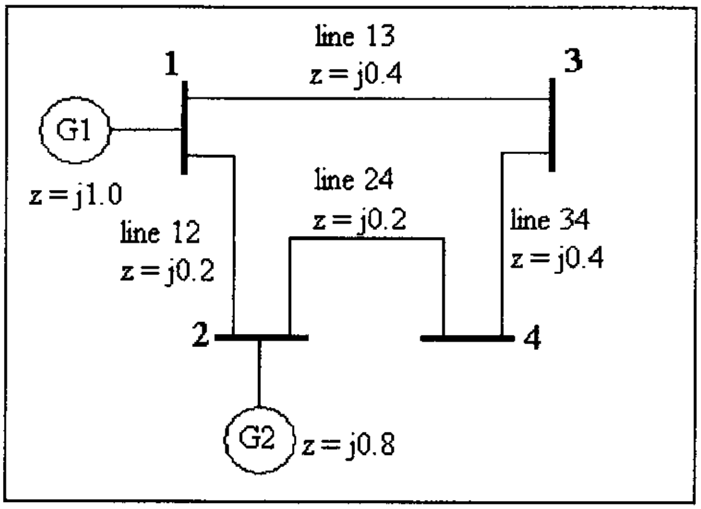

Figure Q3(b)

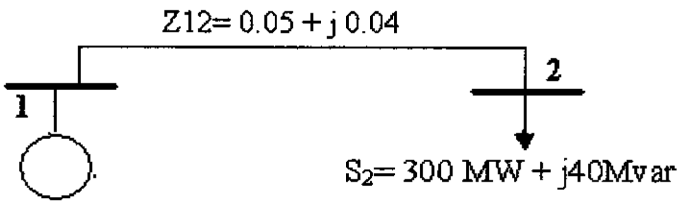

Figure Q3(c)

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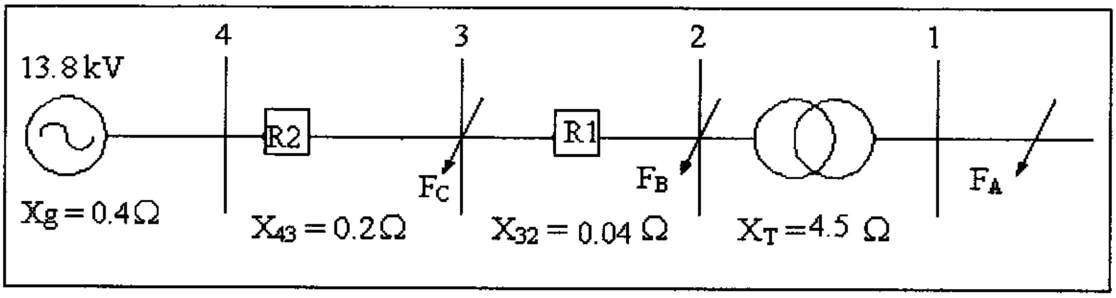

Figure Q4(b)

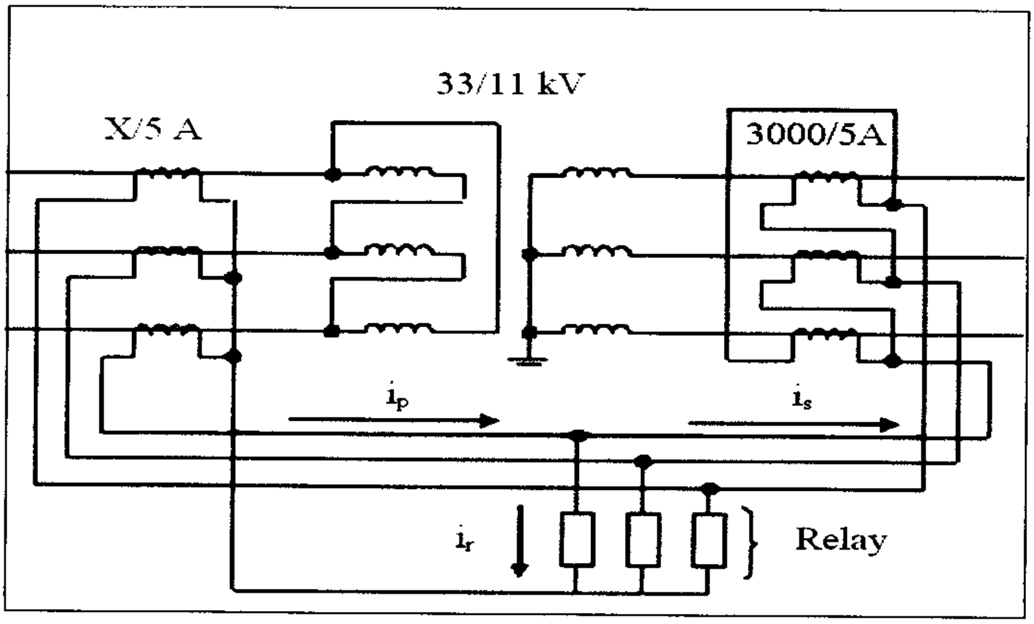

Figure Q4(c)

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Conversion of a given base per-unit impedance on a new base:

$$Z_{new(pu)} = Z_{old(pu)}\left(\frac{kV_{base(old)}}{kV_{base(new)}}\right)^2\left(\frac{MVA_{base(new)}}{MVA_{base(old)}}\right)$$

Short Transmission Line Equation (π – network circuit)

$$\boldsymbol{V_S = AV_R + BI_R}$$
$$\boldsymbol{I_S = CV_R + DI_R}$$

where:

A = 1, B = Z, C = 0, D = 1

Medium Transmission Line Equation (π – network circuit)

$$\boldsymbol{V_S = AV_R + BI_R}$$
$$\boldsymbol{I_S = CV_R + DI_R}$$

where:

$$\boldsymbol{A = D = \left(1 + \frac{ZY}{2}\right)}$$
$$\boldsymbol{B = Z}$$
$$\boldsymbol{C = Y\left(1 + \frac{ZY}{4}\right)}$$

Nodal equation in matrix form

$$V_{bus} = Z_{bus}\, I_{bus}$$

Gauss-Seidel Power Flow Solution

$$v_i^{(k+1)} = \frac{\dfrac{P_i^{sch} - jQ_i^{sch}}{V_i^{*(k)}} + \sum y_{ij} V_j^{(k)}}{\sum y_{ij}} \qquad j \neq i$$