UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2009/2010

SUBJECT NAME	:	ELECTRICAL POWER SYSTEMS
SUBJECT CODE	:	BEE 3243
COURSE	:	3 BEE
EXAMINATION DATE	:	NOVEMBER 2009
DURATION	:	2 HOURS 30 MINUTES
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS FROM SIX (6) QUESTIONS

THIS PAPER CONTAINS OF 13 PAGES

Q1 (a) One-line diagrams are widely used in three-phase power systems studies.

(i) Give three advantages of one-line diagrams.

(3 marks)

(ii) Simplify the one-line diagram as depicted in Figure Q1(a) into a reactance diagram.

(2 marks)

(b) The one-line diagram of a three-phase power system is shown in Figure Q1(b). The generator has a synchronous reactance of 0.18 p.u. The line length is 65 km with resistance and reactance of 0.4 Ω/km and 0.8 Ω/km, respectively. Using a common base of 100 MVA and 30 kV on the generator side,

(i) find new per-unit impedance for each component of the electrical system.

(12 marks)

(ii) Sketch a reactance diagram based on the values given in Q1b(i).

(2 marks)

(c) Electricity is the flow of electrical power or charge from one point to another. The energy conversion can be categorized as conventional sources and renewable sources.

(i) Explain briefly the differences between the conventional and the renewable sources.

(2 marks)

(ii) Give 2 examples for each category of the sources.

(4 marks)

Q2 (a) The effect of armature reaction is one of the factor causing the difference between internal generated voltage of a synchronous generator, E_A and its per phase output voltage, V_Φ.

(i) Explain the occurrence of armature reaction in a synchronous generator

(4 marks)

(ii) State the final equation of V_Φ after taking into consideration the armature reaction, self inductances and resistance of armature coils.

(1 mark)

(b) Consider the three-phase transposed line conductors in Figure Q2(b). Calculate the line phase spacing, D in meters when the system frequency is given as 50 Hz and the line reactance is 0.405 Ω per kilometre. The radius of the conductor is given as 2.0 cm.

(7 marks)

(c) A 40 MVA, 25 kV, 1000 rev/min, 3-phase generator has a synchronous reactance (X_s) of 5 Ω per phase and is connected to an infinite busbar. If the exciting voltage is 14.3 kV (line-to-neutral), the system voltage is measured as 24 kV (line-to-line). Based on the standard power supply frequency in Malaysia, determine

(i) the number of poles of the rotor,

(1 mark)

(ii) the torque angle δ when the generator delivering 60 MW,

(3 marks)

(iii) the maximum power delivered by the generator before it falls out of step (out of synchronism).

(3 marks)

(d) Hydropower stations can be divided into three types based on their heads. List and explain briefly these three types of hydropower station.

(6 marks)

Q3 (a) Transmission lines can be classified into three groups which are short transmission line, medium transmission line and long transmission line.

(i) Define the medium transmission line.

(1 mark)

(ii) Draw and label the complete nominal-π circuit for medium transmission line.

(4 marks)

(b) A 132kV, three-phase transmission line is connected to a 50MW load at 0.85 power factor lagging. The length of the transmission line is 88km. The series impedance and the shunt admittance is $Z = 95\angle 78°\Omega$ and $Y = 0.001\angle 90° S$, respectively. By using the equivalent nominal-π circuit, calculate,

(i) the sending end voltage, V_s and sending end current, I_S.

(8 marks)

(ii) the sending end power and line efficiency.

(2 marks)

(c) A 220 kV, 150 MVA, 50 Hz three-phase transmission line is 260km long. The characteristic parameters of the transmission line are given as

$r = 0.12\ \Omega/km$

$x = 0.98\ \Omega/km$

$y = 5.1 \times 10^{-6}\ S/km$

The voltage at the receiving end of the transmission line is given as 210 kV. Find the ABCD parameters of this transmission line.

(10 marks)

Q4 (a) Power flow study involves numerical analysis applied to power systems.

(i) Give two methods used in power flow analysis.

(2 marks)

(ii) Give three types of network buses in power flow analysis.

(3 marks)

(b) The nodal admittance equations in matrix form are given as

$$\begin{bmatrix} -j16.75 & j11.75 & j2.50 \\ j11.75 & -j19.75 & 0 \\ j2.50 & 0 & -j5.80 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 0 \\ 1.20\angle -80^\circ \\ 0.85\angle -120^\circ \end{bmatrix}$$

(i) By using Gaussian elimination, solve the nodal equations to find the bus voltage.

(10 marks)

(ii) Find the $Y_{bus(new)}$ using Kron reduction method when node 3 is removed from the nodal admittance equation matrix.

(4 marks)

(c) Figure Q4(c) shows the admittance diagram of a simple three bus power system with generation at bus 1. The magnitude of voltage at bus 1 is adjusted to 1.05 per unit. The scheduled loads at buses 2 and 3 are as marked on the diagram. Line admittances are marked in per unit on a 50 MVA base and the line charging susceptances are neglected. With initial estimation of $V_2^{(0)} = 1.0 + j0.0$ and $V_3^{(0)} = 1.0 + j0.0$, determine the value for $V_2^{(1)}$ and $V_3^{(1)}$ using Gauss Seidel method. Solve the equations accurate to four decimal places.

(6 marks)

Q5 (a) The most common power network analysis studies can be divided into 2 major types.

(i) List these two types of power network analysis studies.

(2 marks)

(ii) Give three types of unsymmetrical faults.

(3 marks)

(b) The one-line diagram of a certain power system is shown in Figure Q5(b). The three-phase power and line ratings for the system are given in Table Q5(b). The MVA base and kV base at G_1 are 1000 MVA and 13.8kV, respectively.

(i) Find the per unit impedances of the systems.

(4 marks)

(ii) Draw and calculate the total impedance for positive sequence, negative sequence and zero sequence.

(6 marks)

(iii) Determine the fault currents (in Amperes) during symmetrical three-phase fault and single line-to-ground fault for a fault point at F.

(3 marks)

(c) The bus admittance matrix for a system shown in Figure Q5(c) is given as

$$Y_{bus} = \begin{bmatrix} -j12.75 & j2.5 & j5.0 \\ j2.5 & -j12.5 & j5.0 \\ j5.0 & j5.0 & -j10.0 \end{bmatrix}$$

Find Z_{bus} by showing all steps of the calculation clearly. Calculate the fault current, $I_3(F)$ in per-unit, bus voltages and the line currents that flow in each line during balanced fault condition by using the bus impedance matrix. The fault impedance, Z_f, is given as j0.24pu.

(7 marks)

Q6 (a) Shunt capacitor banks are widely used to improve the quality of the electrical supply and the operation efficiency of the power system.

(i) Give two advantages of the shunt capacitor bank to the power system

(2 marks)

(ii) Give 3 benefits to the power system when the shunt capacitor banks are installed in the system

(3 marks)

(b) Consider a Δ/Y-connected, 15 MVA, 33/11-kV transformer shown in Figure Q6(b) with differential protection applied. The CT ratio at the secondary side is 2000/5 A and at the primary side is X/5 A. The minimum relay current setting is i_r=1.206 A with 125% overload.

(i) Calculate the relay current on full load.

(2 marks)

(ii) Calculate the CT current on the primary side when the current on the secondary side is 3.41 A.

(3 marks)

(iii) Determine the ratio of the CT at primary side.

(8 marks)

(c) Figure Q6(c) shows the radial system with protection scheme. Analyse and explain the operation of the protection scheme clearly.

(7 marks)

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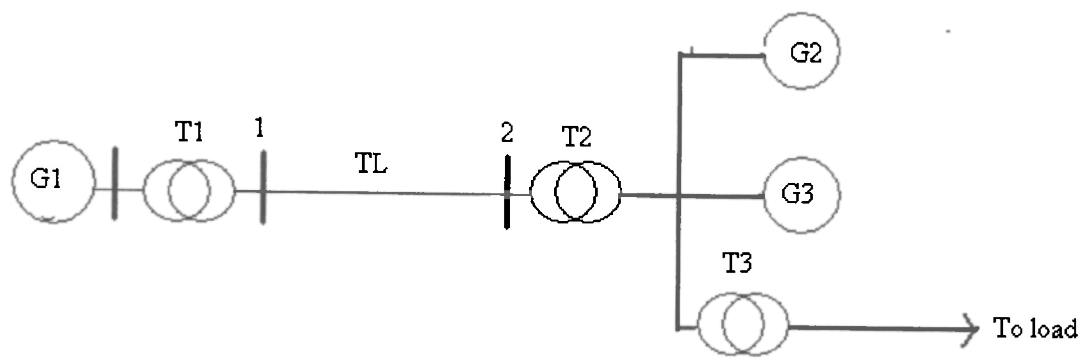

Figure Q1(a)

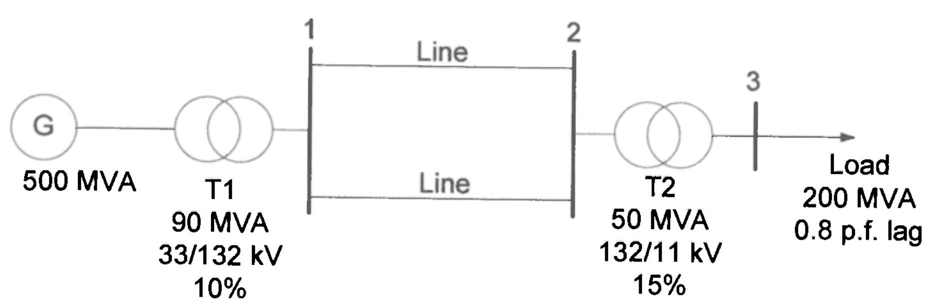

Figure Q1(b)

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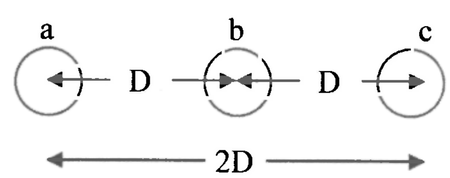

Figure Q2(b)

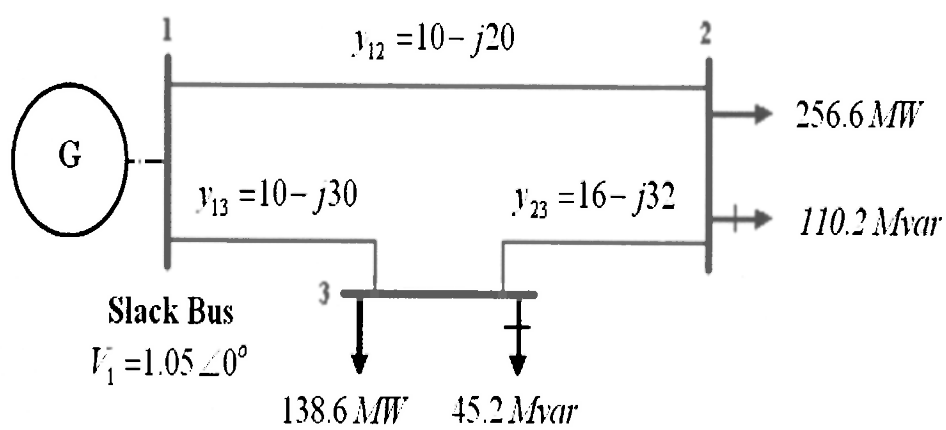

Figure Q4(c)

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Table Q5(b)

Components	MVA rating	KV rating	X_1	X_2	X_0
G_1	500	13.8	j0.20 pu	j0.20 pu	j 0.05 pu
G_2	750	13.8	j0.18pu	j0.18pu	j0.09pu
G_3	1000	13.8	j0.17pu	j0.17pu	j0.10pu
T_1	500	13.8/500	j0.05 pu	j0.05pu	j0.05pu
T_2	750	500/13.8	j0.09pu	j0.09pu	j0.09pu
T_3	1000	500/13.8	j0.10pu	j0.10pu	j0.10pu
$TL_1 = TL_2 = TL_3$			50 Ω	50 Ω	100Ω

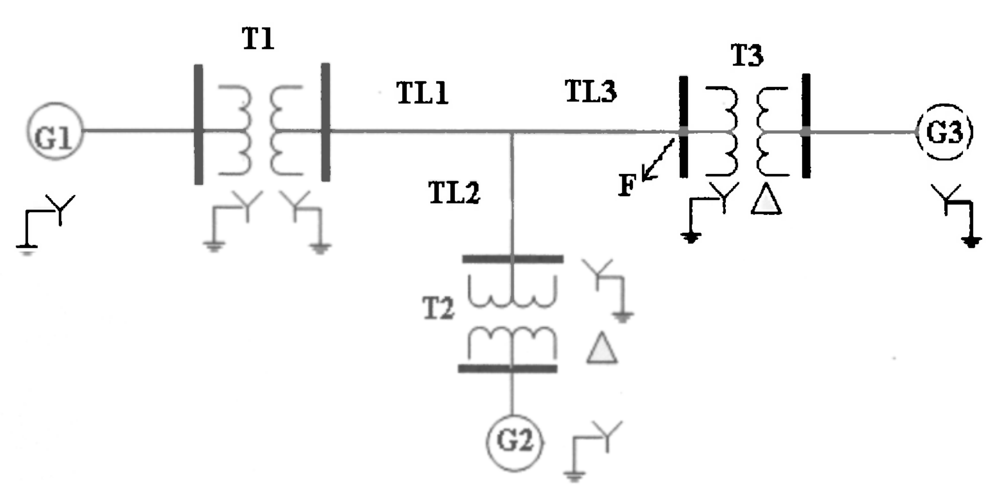

Figure Q5(b)

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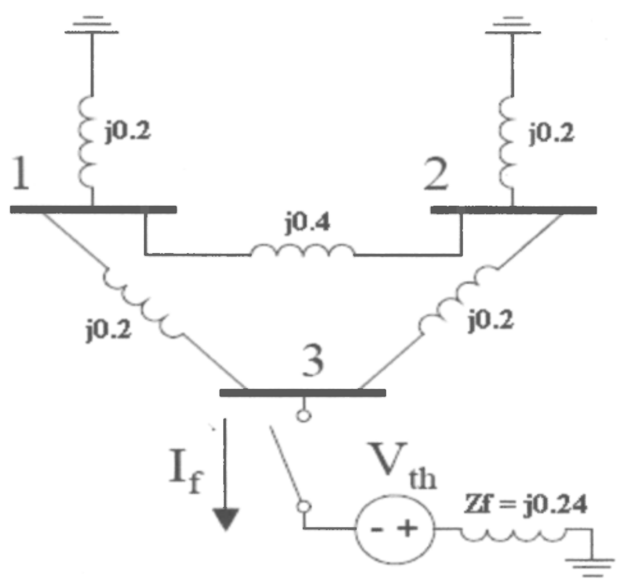

Figure Q5(c)

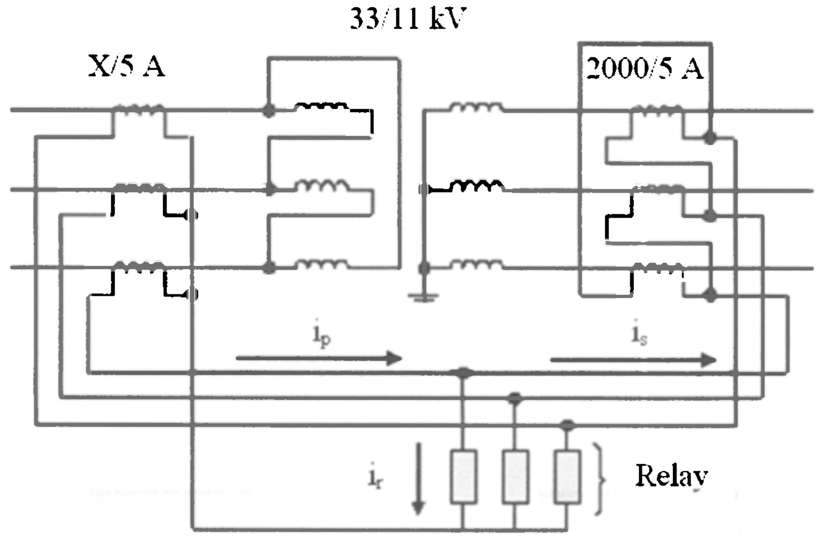

Figure Q6(b)

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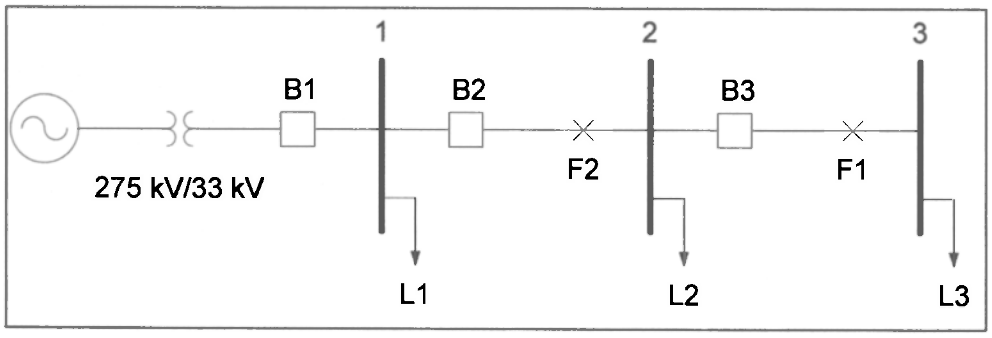

Figure Q6(c)

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Medium Transmission Line Equation (π – network circuit)

$$V_S = AV_R + BI_R$$
$$I_S = CV_R + DI_R$$

where:

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

Nodal equation in matrix form

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

Gauss-Seidel Power Flow Solution

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