UNIVERSITI TUN HUSSEIN ONN MALAYSIA

PEPERIKSAAN AKHIR
SEMESTER II
SESI 2008/09

NAMA MATA PELAJARAN	:	SISTEM KUASA ELEKTRIK
KOD MATA PELAJARAN	:	BEE 3243
KURSUS	:	3 BEE
TARIKH PEPERIKSAAN	:	APRIL / MEI 2009
JANGKA MASA	:	2 ½ JAM
ARAHAN	:	JAWAB EMPAT (4) SOALAN SAHAJA DARIPADA ENAM (6) SOALAN.

KERTAS SOALAN INI MENGANDUNGI TIGA BELAS (13) MUKA SURAT

Q1 (a) Explain the definition of impedance diagram and reactance diagram. Support your explanation with appropriate example.

(5 marks)

(b) Figure Q1(b) shows a power system consisting of a three-phase 480 V, 50 Hz generator that supplying a load through a transmission line. The impedance of transmission line is equal to $1.5 + j10\ \Omega$ while the impedance of star connected Load 1 is equal to $0.5\angle 36.87^\circ\ \Omega$. The excitation voltage of the generator is maintained at 480 V throughout the operation. A common base of 1000 kVA and 480 V is used at the load side. For the corresponding system:

(i) Construct the impedance diagram for the system
(ii) Calculate the per unit current that flows within the transmission line and the input power factor for the system
(iii) Determine the per unit apparent power, real power and reactive power delivered by the generator

(12 marks)

(c) Figure Q1(c) represents a power system that is similar to Figure Q1(b) except with additional load denoted as Load 2. The impedance of Load 2 is given as $-j0.833\Omega$. The excitation voltage of the generator is maintained at 480 V throughout the operation. A common base of 1000 kVA and 480 V is used at the load side.

(i) Develop the impedance diagram for the system
(ii) Calculate the per unit current injected by generator into system.
(iii) Determine the total per unit apparent power, real power and reactive power received by transmission line and load
(iv) Compare the effect of adding Load 2 to the power factor of the system in Figure Q1(c) to the power factor of the system in Figure Q1(b)

(8 marks)

Q2 (a) For common generator application, usually there is more than one generator operating in parallel to supply the power demanded by the loads. Draw the equivalent circuit and phasor diagram of the two generators operating in parallel and explain about the phasor diagram.

(5 marks)

(b) A large grid system is connected with a three-phase synchronous generator with the rating of 500 MVA, 18 kV, 15 pairs of poles and 50 Hz. The excitation voltage, E, of the generator is $18.5\angle\delta_1{}^\circ$ kV (line-to-line), and the terminal voltage, V_T, at the grid system is $18.25\angle 15^\circ$ kV (line-to-line).

The synchronous generator has synchronous reactance of 0.85 Ω per phase.

(i) Find the speed of the rotor, n and the type of the rotor

(ii) Find the voltage phasor angle, δ_1 of the excitation voltage, E if the synchronous generator is delivering 15 MW per phase power to the grid system

(iii) Calculate the maximum power, P_{max} of the generator in its synchronism condition

(iv) Draw the power curve (P versus δ) of the generator for the condition in Q2(b)(iii) and label the maximum active power, P_{max} and its maximum angle, δ_{max}

(7 marks)

(c) North Hoyle is the first offshore wind farm built in United Kingdom. It consists of 30 wind turbines where each wind turbine has a rotor blade with diameter of 126 meters. It is given that the wind velocity is equal to 36 km per hour and the air density at sea level is 1.23 kg/m^3.

(i) Calculate the kinetic energy produced by 1 m^3 of moving air

(ii) Calculate the power produced by this wind turbine

(iii) If the turbine is connected with a 6 poles, 50 Hz synchronous generator, calculate the speed of the rotor, n and what is the type of the rotor?

(7 marks)

(d) Suggest three ways to overcome the disadvantages of the wind power generation system.

(6 marks)

Q3 (a) Standard voltages are grouped into four main classes. Name them and state the approximate voltage range of each.

(4 marks)

(b) Explain the following:

(i) Efficiency of the transmission line
(ii) Regulation of the transmission line

(1 mark)

(c) A three-phase, 50Hz, 230 kV transmission line having a length of 90 km is composed of three ACSR conductor having a cross-section of 1000 kcmil. The voltage of the source is 230 kV (line-to-line) and that at the three-phase load of 381 MVA at 0.8 power factor lagging at 220 kV. Table Q3(c)(i) gives typical values of the inductive and capacitive reactances per kilometer for practical transmission line operating at 50Hz. Table Q3(c)(ii) gives the resistance and ampacity for several overhead line conductors. Using the nominal π-network circuit representation :

(i) Find the values of series impedance, shunt admittance of this transmission line and draw the equivalent circuit per phase

(4 marks)

(ii) Find the sending-end voltage, V_s and the sending-end power, P_s

(4 marks)

(iii) Find the voltage regulation and efficiency of the transmission line

(3 marks)

(iv) If the line supplies change to 381 MVA load at unity power factor. Compare and explain the voltage regulation and efficiency of the transmission line with the results Q3(c)(iii)

(6 marks)

(v) Sketch and label the complete three-phase circuit for Q3(c)(iv)

(3 marks)

Q4 (a) Explain briefly about modification of Z bus in power system.

(5 marks)

(b) Figure Q4(b)(i) and Figure Q4(b)(ii) is the admittance and impedance diagram respectively, of a two bus power system network.

(i) Find the value of excitation voltage Ea_1 and Ea_2

(ii) Calculate Y_{11}, Y_{22} and gives the bus admittance matrix of the network

(iii) Obtain the bus impedance matrix by inverting the bus admittance matrix

(iv) Calculate the voltage of V_1 and V_2.

(5 marks)

(c) For the small network shown by Figure Q4(c), bus 1 is a slack bus with $V_1 = 1\angle 0°$ pu. A load of 150 MW and 50 MVAR is taken from bus 2. The line impedance is $z_{12} = 0.028 + j0.096$ pu on a base of 100 MVA. Using Newton Raphson method, generate the voltage magnitude and phase angle of bus 2. Start with an initial estimate of $|V_2|^{(0)} = 1.0$ pu and $|\delta_2|^{(0)} = 0°$. Perform one of iteration and write your answer up to four decimal places.

(15 marks)

Q5 (a) Fault can cause over current at certain point of power system.

(i) Give two causes that can make fault occur in a power system.

(2 marks)

(ii) Give three main purposes of fault analysis.

(3 marks)

(b) A single-line diagram of the power system is shown in Figure Q5(b). The three-phase power and line ratings for the system are given as follows;

Component	MVA Rating	kV Rating	X^1	X^2	X^0
G1	25MVA	10kV	j0.10 pu	j0.10 pu	j .05 pu
T1	20MVA	10/69kV	j0.05 pu	j0.05pu	j0.05pu
TL1	25MVA	69kV	j0.09pu	j0.09pu	j0.09pu
T2	20MVA	69/10kV	j0.10pu	j0.10pu	j0.10pu
G2	10MVA	10kV	j0.10pu	j0.10pu	j0.05pu

S base and Vbase are 25 MVA and 10kV respectively, referring to G1.

(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

(3 marks)

(ii) If fault occur at point F, determine the fault current (in Ampere) during symmetrical three-phase fault and single line to ground fault

(6 marks)

(c) There are three types of faults for unsymmetrical fault; single line to ground fault, line to line fault and double line to ground fault. For single line to ground fault,

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

Show all steps clearly with the aid of appropriate diagrams to prove the equation.

(7 marks)

Q6 (a) There are three different ways in which the primary distribution lines can be laid which are radial primary circuit, loop primary circuit and ring main system.

(i) Develop and draw the Radial Primary Circuit

(2 marks)

(ii) Discuss three advantages of using the Radial Primary Circuit

(3 marks)

(b) Consider the radial system in Figure Q6(b), calculate the fault currents at F_1, F_2, F_3, F_4 and F_5 when the system voltage is 13.8 kV. Propose relay settings on the basis of current grading, assuming a 50% relay error margin for relay at 1, 2 and 5. Given $X_g = 0.5\ \Omega$, $X_{12} = 0.1\ \Omega$, $X_{23} = 0.05\ \Omega$, $X_{34} = 1.2\ \Omega$ and $X_{45} = 0.5\ \Omega$.

(8 marks)

(c) Transformer connection and ratio should be taken to apply the principles of differential protection to three phase transformer. Consider a Δ/Y-connected, 20 MVA, 33/11-kV transformer with differential protection applied for the current transformer ratios at primary site is 300/5 A and for secondary site is 2000/5 A:

(i) Develop and draw the protection scheme for the three phase transformer with the Δ/Y- connected

(4 marks)

(ii) Calculate the relay current on full load based on the protection scheme of (c)(i)

(6 marks)

(iii) Propose the minimum relay current setting to allow 115 % overload

(2 marks)

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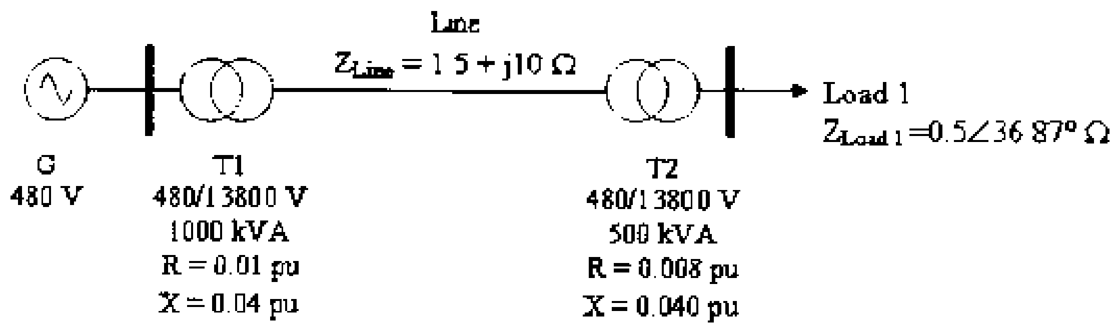

Figure Q1(b)

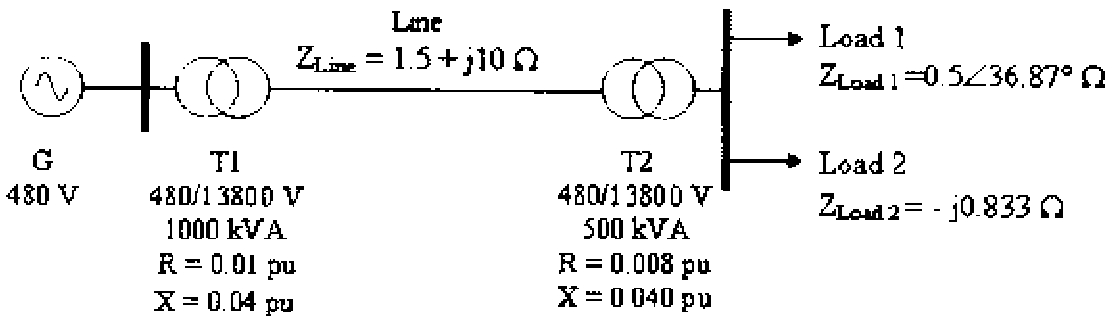

Figure Q1(c)

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Table Q3(b)(i) : Typical Impedances Values Per Kilometers for three-phase, 50Hz lines

Type of line	$x_L(\Omega)$	$x_c(s)$
Overhead line	0.5	300μ

Table Q3(b)(ii) Resistance and ampacity of some bare overhead line conductors.

Conductor Size	Resistance per conductor at 75°C			Ampacity in free air*	
AWG	Cross-section (mm2)	Copper [Ω/km]	ACSR[Ω/km]	Copper[A]	ACSR[A]
300 kcmil	152	0.14	0.22	600	500
600 kcmil	304	0.072	0.11	900	750
1000 kcmil	307	0.045	0.065	1300	1050

*The ampicity indicated is the maximum that may be used without weakening the conductor by overheating. In practice, the actual line current may be only 25 percent of the indicated value

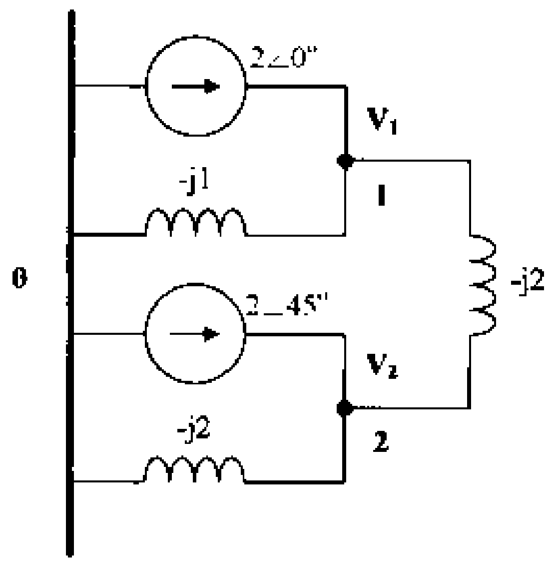

Figure Q4(b)(i)

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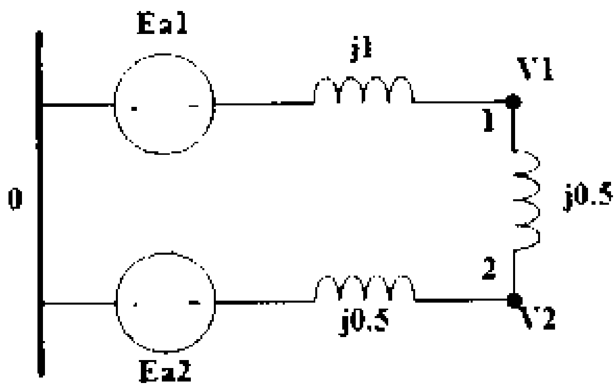

Figure Q4(b)(ii)

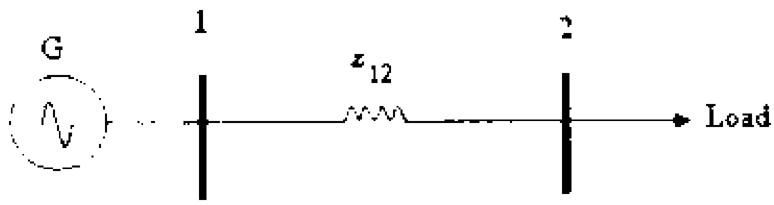

Figure Q4(c)