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THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
HIGHER DIPLOMA IN TECHNOLOGY
ECX4252 –POWER SYSTEMS I
FINAL EXAMINATION - 2014/2015
DURATION – 3 hrs. **CLOSED BOOK**

Date: 05th September 2015 **Time: 09.30 - 12.30 hrs.**

Instructions:

This paper consists of seven (07) questions. Answer any five (5) questions. All questions carry equal marks

Permeability in free space (μ_0) = $4\pi \times 10^{-7}$ Hm^{-1}

Permittivity in free space (ε_0) = 8.85×10^{-12} Fm^{-1}

Q1.

I. A three phase, star connected, 400 V, 50 Hz generator supplies power to following loads;

- Three phase star connected induction motor rated at 25 hp having an efficiency of 90.5% operating at power factor 0.707 lagging,
- Synchronous motor of 30 kW at power factor 0.9 leading
- 10 kW three phase electric heater

Calculate;

a) Total apparent power supplied by the generator [4]

b) Generator line current and power factor [3]

c) A star connected capacitor bank is connected to the generator to raise the power factor to unity. Determine per phase capacitance of the capacitor bank [5]

1hp=746 W

II. A single phase load consists of a resistor and a capacitor connected in parallel. The voltage applied to the load is 230 V and magnitude of the total load current is 10 A. Active power consumed by the load is 1500 W. Calculate the reactive power generate by the load. What would be the reactance of the capacitor? [8]

Q2. A 50 Hz, 200 km long three phase overhead transmission line has per phase parameters; R=21Ω, L= 320.8 mH and C= 1.5 μF. The line supplies a 112 MVA, star connected load at 220 kV operating at 0.9 power factor lagging.

Using the nominal pi (π) network model, for the transmission line, Calculate:

a) Sending end voltage and current [8]

b) Power factor and power delivered at the sending end [8]

c) Transmission efficiency [4]

Q3. A three phase, double circuit, transposed overhead transmission system is shown in Figure Q3.1. The diameter of each conductor is 12.27 mm. Resistivity and temperature coefficient of the Conductor material at 20°C are 1.78×10^{-8} Ωm and 0.00382 $^{\circ}C^{-1}$ respectively. The tower configuration of the above double circuit overhead transmission system is shown in Figure Q3.2

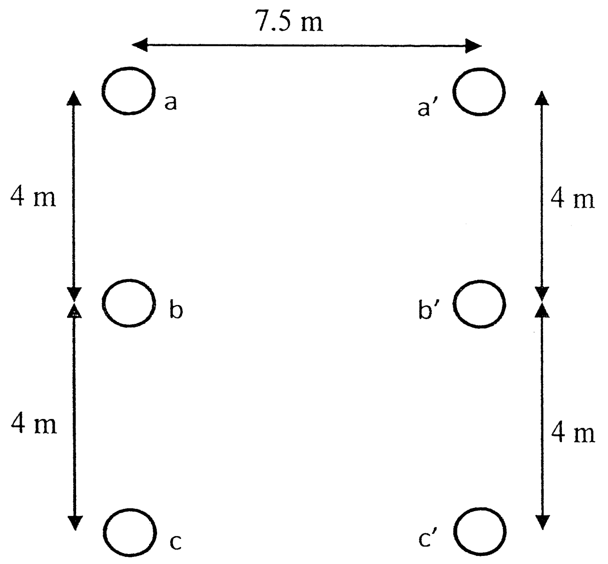

Figure Q3.1

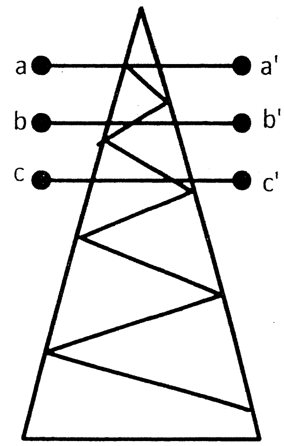

Figure Q3.2

I. What are the effects of having irregular spacing's of conductors in overhead transmission system and state the action that has to be taken to avoid it. [3]
II. Calculate, the self GMD and mutual GMD [6]
III. Determine, per unit length inductance and capacitance of the line [4]
IV. If the length of the transmission line is 250 km and ambient temperature is 45 °C, calculate per-phase parameters of the equivalent π model of the transmission line [7]

Q4.

I. The arc interruption in a certain circuit breaker in a power system may be represented by an oscillation circuit with inductance of 25.5 mH and a capacitance to neutral of 0.02 μF. If the supply voltage to neutral is 14.14 kV(R.M.S) at a frequency of 60 Hz. Determine;
   a) Voltage across the contacts of the circuit breaker when it breaks a short circuit current at zero value. [4]
   b) Frequency of the Re-striking voltage transient [2]
   c) Rate of Rise of Re-Striking voltage [2]

II. A single core cable consisting of a 2cm diameter conductor inside a 5 cm diameter sheath is 15 km long and operates at 13.2 kV and 60 Hz. The relative permittivity of the dielectric is 5 and open circuit power factor of the cable is 0.087. Calculate;
   a) Capacitance of the cable [2]
   b) Charging current [2]
   c) Insulation resistance [4]
   d) Dielectric loss [4]

Q5.

I. List the types of short circuit faults in a power system according to their frequency of occurrence increases [4]

II. A generator supplying power to two motors through an overhead transmission line is shown in Figure Q5.

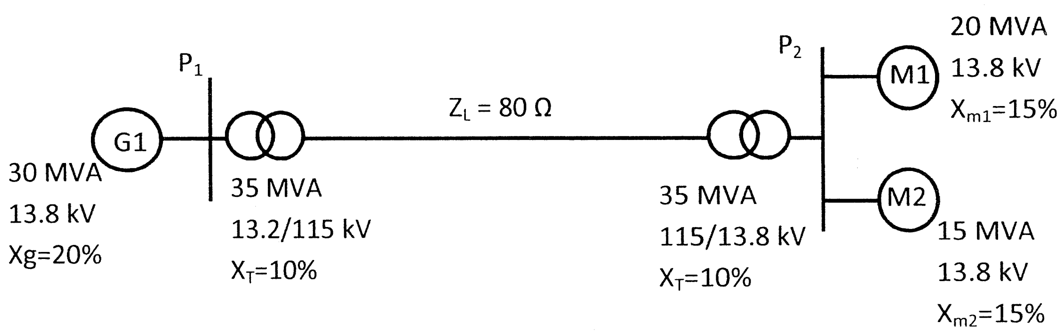

Figure Q5

a) Convert all quantities to a common base of 30 MVA, and 13.8 kV on the generator G1 side and draw the reactance diagram with values expressed in p.u. [10]

b) If voltage at point P_2 is maintained at 1.0 p.u and the two motors are running at their rated conditions at power factor 0.7 lagging, calculate the voltage at point P_1 in kV. [6]

Q6. A single line diagram of a certain power system is shown in Figure Q6. Reactances of the elements are given to a common base values as indicated in the Table Q6. The generators A, B and C generates their voltage at 1.0 p.u. on common base.

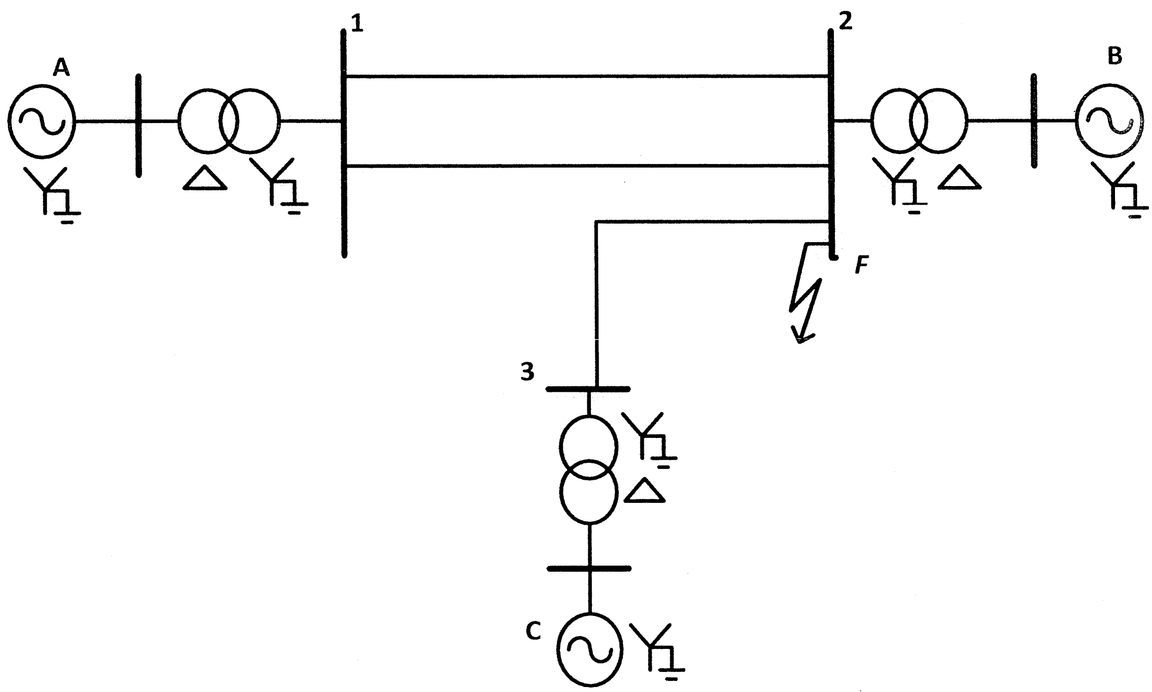

Figure Q6

Table Q6

Equipment	Positive Sequence impedance	Negative Sequence impedance	Zero Sequence impedance
Generator A	j0.25	j0.15	j0.02
Generator B	j0.2	j0.15	j0.03
Generator C	j0.25	j0.2	j0.05
Transmission lines (1-2 and 2-3)	j0.3	j0.3	j0.8
Transformers	j0.12	j0.12	j0.12

I. Draw positive, Negative and Zero sequence networks for the Figure Q6 [12]
II. Draw an equivalent sequence network when the fault at F is a single line to ground fault [5]
III. Calculate the line fault current in p.u. at fault point [3]

Q7. An industrial factory, supplied with three phase, 400 V supply has two sections S1 and S2. The variations of loads during a day in each section "L_{S1}" and "L_{S2}"are given in Table Q7.1. Power factors of loads L_{S1}, L_{S2} are 0.95 (lag) and 0.85 (lag) respectively. The power factors of the loads remains above values right thought the day.

Table Q7.1

Time	L_{S1}(kVA)	L_{S2} (kVA)
Mid night – 6.00 a.m.	15	18
6.00 a.m. – 10.00 a.m.	25	20
10.00 a.m. – 1.00 p.m.	60	45
1.00 p.m. – 6.00 p.m.	45	45
6.00 p.m. – Mid night	30	25

I. Calculate the total active and reactive power consumed by the factory at the given time periods [8]
II. Hence compute the maximum demand [3]
III. Plot the Daily load demand curve of this factory [3]
IV. Calculate the cost for electricity per month [6]

[Tariff plan of the Industrial customers metered at the 400/230 V is given by Table Q7.2 in page 5 of 5]

Table Q7.2

Tariff plan
Industrial Purpose

Energy charge (LKR/kWh)			Fixed Charge (LKR/ month)	Maximum Demand Charge per month (LKR/kVA)	Fuel adjustment charge (% of Energy Charge)
Peak (1 p.m. – 6 p.m.)	Off-Peak (6 p.m. - 6 a.m.)	Day (6 a.m. - 1 p.m.)			
21.00	7.00	11.30	3,000	1,100	15