MACHAKOS UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

2015/2016 SUPPLEMENTARY EXAMINATIONS

FOURTH YEAR EXAMINATIONS FOR THE BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 404 POWER SYSTEMS II DURATION: 2 HOURS DATE: AUGUST 2017

Instructions:

This paper consists of **Five** questions. Answer question **One** and any other **TWO**

1

(a) A 3-phase 20 MVA, 10 kV alternator has internal reactance of 5% and negligible resistance. Find the external reactance per phase to be connected in series with the alternator so that steady current on short circuit does not exceed 8 times the full load current. **(8 marks)**

(b) Estimate the distance over which a load of 15000 kW at a p.f of 0.8 lagging can be delivered by a 3-phase transmission line having conductors each of resistance 1Ω per kilometer. The voltage at the receiving end is to be 132 kV and the loss in the transmission is to be 5% **(8 marks)**

(c) A three phase 50 Hz 66 kV overhead line conductor are placed in a horizontal plane as shown in Figure 2. The conductor diameter is 1.25 cm. If the line length is 100 km, calculate

i. Capacitance per phase

ii. Charging current per phase **(8 marks)**

Assume complete transposition

(d) Explain with the aid of a diagram the following terms as applied to a three phase system.

i. Positive sequence component

ii. Negative sequence component

iii. Zero sequence component **(6 marks)**

2

(a) Starting from the Ampere law, show that the total flux linkages round a conductor of radius r carrying current I is given by:

$$\frac{\mu_0 I}{2\pi}\left[\frac{1}{4}+\int_r^\infty \frac{dx}{x}\right] weber\ turn\ /\ m\ length$$

(14 marks)

(b) Show that the Inductance of a Single phase two wire line with conductor radius of r metres separated by distance d is given by:

$$\frac{\mu_0}{\pi}\left[\frac{1}{4}+ln\frac{d}{r}\right]\ \ H/m$$

(8 marks)

(c) Three conductors, each of diameter 1.24cm, of a 3-phase line are arranged at the corners of a triangle of sides 2m, 2.5m and 4.5m. Calculate the inductance per km of the line when the conductors are regularly transposed. **(4 marks)**

3

(a) Draw the equivalent circuit of a single phase short transmission line explaining all the parameters shown. **(4 marks)**

(b) Draw the phasor diagram of the line for lagging power factor **(4 marks)**

(c) A single phase overhead transmission line delivers 1100 kW at 33kV at 0.8 pf lagging. The total resistance and inductive reactance of the line are 10Ω and 15Ω respectively. Determine:

i. Sending end voltage **(6 marks)**

ii. Sending end power factor **(3 marks)**

iii. Transmission efficiency. **(3 marks)**

4

(a) Explain using diagrams, two methods of locating the reactors for control of short circuit current to ensure that minimum voltage drop and power loss during normal operation. **(8 marks)**

(b) A 3-phase transmission line operating at 10 kV and having a resistance of 1Ω and reactance of 4Ω is connected to the generating station bus-bars through 5MVA step-up transformer having a reactance of 5%. The bus-bars are supplied by a 10 MVA alternator having 10% reactance. Calculate the short-circuit kVA fed to symmetrical fault between phases if it occurs

i. At the load end of the transmission line **(9 marks)**

ii. At the high voltage terminals of the transformer **(3 marks)**

5

The two generators shown in Figure 1 are identical, each rated 13.8kVand 50MVA with a sub- transient reactance of X_d" = 15%. The two generators are tied to a common bus which is connected to a transmission line with a delta-grounded wye transformer rated at 150MVA, 13.8kV/115kV and an impedance of 9.7%. The transmission line is 30 miles long and has an impedance of 5.43 + j22.5Ω. At the end of the transmission line is a grounded wye-grounded wye transformer, rated 225MVA, 115kV/230kV with an impedance of 7.4% that connects the line to a 230kVbus. The remaining power system connected to the 230kV bus is not shown.

Each generator has a zero-sequence reactance of 5% and is grounded through a reactance of 2Ω. The transmission line has a zero-sequence impedance of 12.9 + j75.9Ω. The grounded wye-grounded wye transformer has a zero-sequence reactance of 4.8%.Use voltage bases of 13.8kV, 115kV, and 230kV for the corresponding parts of the system, and use a power base of 100MVA for the whole system.

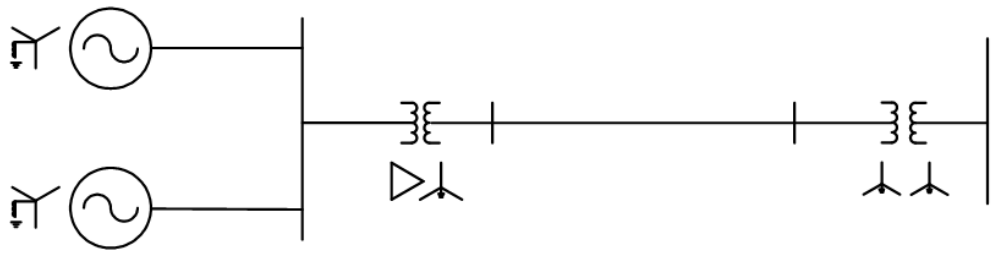

Figure 1

(a) From the above information, draw the impedance diagram with impedances shown in their per-unit values **(8 marks)**

(b) Draw the positive, negative and zero-sequence impedance networks for the power system with impedances shown in their per-unit values.

(11 marks)

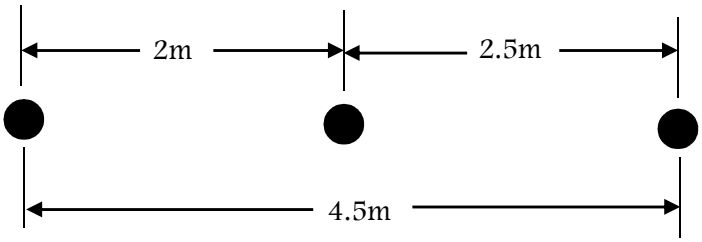

Figure 2