University of KwaZulu-Natal
Electrical, Electronic & Computer Engineering
Main Examinations: November 2016

DURATION: 3 HOURS **TOTAL MARKS: 90**

Examiners: Dr. Saha (Internal_Section 1)
Dr R. Tiako (Internal_Section 2)
Dr A. Swanson (Moderator)

Instructions:
1. Your answers to Sections 1 and 2 must be submitted in **separate** examination books
2. Answer **all** questions: **five** from Section 1 and **three** from section 2
3. Scientific calculators may be used provided their **memories** have been **cleared**
4. Answers may be written in a **dark** pencil

`

Section 1: Full Marks: 50 ; Weight: 50

[Answer **all five** questions from this section in a separate examination book, and label the front cover of this book clearly as **SECTION 1**]

QUESTION 1

The cost of three-phase overhead is R (150a+10000) per km length where a is the cross-sectional area of the conductor in sq mm. The rate of interest and depreciation per annum is 10%. If the load is supplied 60% of the year, estimate the most economical current density for the conductor. The cost of energy is 15 cent per kWh and resistivity of conductor material is 1.8 μ ohm-cm. **[11]**

QUESTION 2

A transmission line has a span of 300 m between level supports. The conductor diameter is 20 mm. the conductor weighs 0.8 kgf/m and has a maximum tensile strength of 7900 kgf. The conductors are subjected to a radial ice-covering of 9.5 mm thickness and sag of 6.5 m. Calculate the horizontal wind pressure acting on the ice-covered projected area of the conductor if the factor of safety is 2.5 and weight density of ice is 913.5 kgf/m^3. **[11]**

QUESTION 3

Fig. 1 shows a twin conductor circuit of a three-phase, 50 Hz overhead transmission line with horizontal spacing of 7 m. Each sub-conductor of the bundle has diameter of 20 mm and spacing between the conductors is 0.4 m. Each phase group shares the total current and charge equally and the transmission line is completely transposed. Determine the inductance/ph/km and inductive reactance per/ph/km of the transmission line. **[10]**

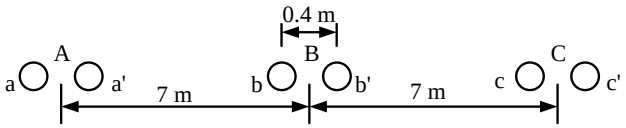

Fig. 1: Twin Conductor Transmission Line

QUESTION 4

In a single-phase underground cable the conductor diameter is 10 mm and there are two layers of insulations in the cable. The inner layer has a maximum potential gradient of 1.2 times that of the outer layer and the radial thickness of insulation of each layer is 4.6 mm. Calculate the voltage across of each layer if the peak value of working voltage for the cable is 6.6 kV. **[10]**

QUESTION 5

A three-phase, 30 MVA, 33 kV star-connected generator has 4% reactance. Find the reactance in ohm per phase to be connected in series with the generator so that steady-state current on a three-phase short-circuit condition does not exceed 10 times the rated full load current. **[8]**

Section 2: Full Marks: 40 ; Weight: 50

[Answer **all three** questions from this section in a separate examination book, and label the front cover of this book clearly as **SECTION 2**]

Question 1 [12.5 Marks]

(a) Briefly answer the following questions:

(i) State one advantage and one disadvantage of the electrical energy. **[1]**

(ii) The "quality" of power supply must meet certain minimum standards with regard to three factors, state those three factors. **[1.5]**

(iii) What are the main differences between generation, transmission and distribution voltage levels? **[1.5]**

(iv) Enumerate the chief sources of energy used for the generation of electrical energy and classify them in groups of steady/intermittent & adverse/friendly. **[2]**

(v) State 3 methods of voltage control in the power system. **[1.5]**

(b) A balanced, positive/abc - sequence, Y – connected voltage source with $\mathbf{E_{ab}} = 480\angle 0^o$ volts is applied to a balanced - Δ load via a short transmission line. $\mathbf{Z}_\Delta = 30\angle 40^o\ \Omega$. The transmission line impedance is $\mathbf{Z_{line}} = 1\angle 85^o\ \Omega$.

(i) Calculate $\mathbf{I_a}$, $\mathbf{I_b}$ & $\mathbf{I_c}$ **[3]**

(ii) Calculate the magnitude of the Δ-load current. **[1]**

(iii) Calculate the real power losses. **[1]**

(iv) Calculate the reactive power absorbed by the load. **[1]**

Question 2 [12.5 Marks]

(a) A single-phase source delivers 120 kW at a power factor of 0.85 lagging.

(i) Calculate the reactive power to be delivered by a capacitor connected in parallel with the load in order to raise the source power factor to 0.95. **[2.5]**

(ii) What is the capacitance value of the selected capacitor? **[2]**

(b) A single phase voltage source with $\mathbf{V} = 100\angle 120^o$ V has a current $\mathbf{I} = 15\angle 10^o$ A, which enters the positive terminal of the source.

(i) Calculate the source real and reactive power, and state whether the source delivers or absorbs each of these. **[2]**

(i) State with proof the type of voltage source (generator or motor) **[1]**

(c) A single phase source supplies power to the three loads connected in parallel: (1) a lighting load drawing 10 kW, (2) an induction motor drawing 10 kVA at 0.9 power factor lagging, and (3) a synchronous motor operating at 10 hp, 85 % efficiency and 0.95 power factor leading (1 hp = 0.746 kW). Determine the real, reactive and apparent power delivered by the source. **[5]**

Question 3 [15 Marks]

(a) A generating station has the following daily load cycle as shown in the table below:

Time (Hours	**Load (MW)**
12 midnight to 6:00 A.M.	40
6:00 A.M. to 10 A.M.	50
10 A.M. to 12 Noon	60
12 Noon to 4 P.M.	50
4 P.M. to 8 P.M.	70
8 P.M. to 12 Midnight	40

(i) Plot the load duration curve. **[2]**
(ii) Find the units generated per day. **[1]**
(iii) Find the load factor of the station. **[1]**

(b) The capital cost of a hydro-power station of 50 MW capacity is R 1000 per kW. The annual depreciation charges are 10 % of the capital cost. The maximum demand on the power station is 40 MW and annual load factor is 60 %. Annual cost of salaries, maintenance charges etc. is R 700000. If 20 % of this expense (annual cost of salaries, maintenance charges etc) is also chargeable as fixed charges, Find the following:

(i) The capital cost and the total annual fixed charges. **[3]**
(ii) The annual units generated and the total annual running charges **[3]**
(iii) Calculate the generation cost in two part form if a royalty (payment) of R 1 per kW per year and 1 cents per kWh generated is to be paid to the community for using the river water for the generation of power. **[2]**

(c) A factory has a maximum load of 240 kW at 0.8 pf lagging with an annual consumption of 50000 units. The tariff is R 50 per kVA of maximum demand plus 10 cents per unit. Determine

(i) The annual bill **[2]**
(ii) The flat rate of energy consumption **[1]**