University of KwaZulu-Natal

Electrical, Electronic & Computer Engineering Discipline

Examinations: November 2013

DURATION: 3 HOURS **TOTAL MARKS: 50, SECTION 1 & 67, SECTION 2**

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Prof Odendal (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 **four** 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

[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

(a) Illustrate Kelvin's economy law graphically. **[3]**

(b) Find the best current density for a 3-ph overhead line if it is used for 6750 hours per year. The conductor costs R 25 per kg with a resistivity of 1.76 micro ohm-cm and density of 8.9 gf per cubic cm. Energy costs R 1.5 per kWh and annual interest and depreciation is 10% of the capital cost of the conductor. **[9]**

Question 2

(a) State the advantages of using bundle conductors for overhead power transmission lines? **[5]**

(b) Fig. 1 shows a triple-conductor single circuit, 3-ph, 50 Hz line with a horizontal spacing of 25 m. Each sub-conductor of the bundle has a diameter of 50 mm and spacing between the sub-conductors is 0.6 m. Each phase group shares the total current equally and the line is completely transposed. Determine the capacitive reactance per phase per km for the line. **[6]**

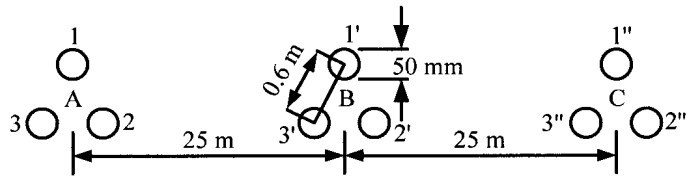

Fig. 1: Three-phase transmission line with bundle conductors

Question 3

(a) Explain briefly how temperature affects sag of an overhead transmission line. **[2]**

(b) An overhead transmission line conductor is having a parabolic configuration with its weight 1.95 kg/m. The area of x-section of the conductor is 2.5 cm^2 and the working strength is 1600 kgf. The supports are 300 m apart having 15 m difference in height. Calculate the sag from the taller of the two towers which must be allowed. Assume that ice load is 1 kg/m and no wind pressure. **[5]**

Question 4

(a) State the limitations of solid power cables used for electrical power transmission and distribution systems. **[3]**

(b) A concentric cable has an inner conductor radius of 10 mm and outer conductor of inside radius of 30 mm. If the instantaneous electric stress in the dielectric is not to exceed 50 kV/cm, calculate the rms value of the allowable sinusoidal alternating potential difference which can be applied to the cable. If this potential difference has a frequency of 50 Hz and the relative permittivity of the dielectric is 2.0, determine the charging current for a cable of 1 km length. . **[7]**

Question 5

A three-phase, 50 MVA, 10.5 kV star-connected generator has 5% 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 8 times the rated full load current. . **[10]**

Section 2

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

Question 1 [17 Marks]

(i) State 4 reasons why electrical energy is preferred over other forms of energy. **[2]**

(ii) State the different sources of energy available in the nature. Which one can be classified as renewable energy sources? Why? **[3]**

(iii) In the tabular form, compare different key factors from different sources of electrical energy using the following adverbs: (1) none, (2) low, (3) high, (4) slow, (5) fast, (6) adverse, (7) less adverse, (8) friendly, (8) steady or (9) intermittent. **[3]**

S.N°	Key factor	Wind	Water	Coal
1	Fuel cost			
2	Steadiness of output			
3	Emission			
4	Environment			

(iv) Write a short note on the principle of generating electrical energy using traditional natural energy sources. **[2]**

(v) Figure 1 represents a voltage regulator and turbine-governor controls for a steam-turbine generator. From the following list: [(1) Exciter, (2) Rectifier/Filter, (3) Steam turbine, (4) Voltage transformer, (5) From steam generator, (6) Governor, (7) Generator, (8) Voltage regulator, (9) To condenser, (10) Main steam valve]. Chose appropriate number corresponding to appropriate letter describing each sub-component in Figure 1. **[3]**

(vi) Based on the schematic in Figure 1, briefly explain using your own words how the terminal voltage at the generator bus and the system frequency are maintained constant (within the standard range). **[2]**

(vii) When the load on the supply system changes, the voltage at the consumers' terminal also changes. The variations of voltage at the consumer's terminals are undesirable and must be kept within prescribed limits. State 4 methods of controlling voltage at terminal load in a power system. **[2]**

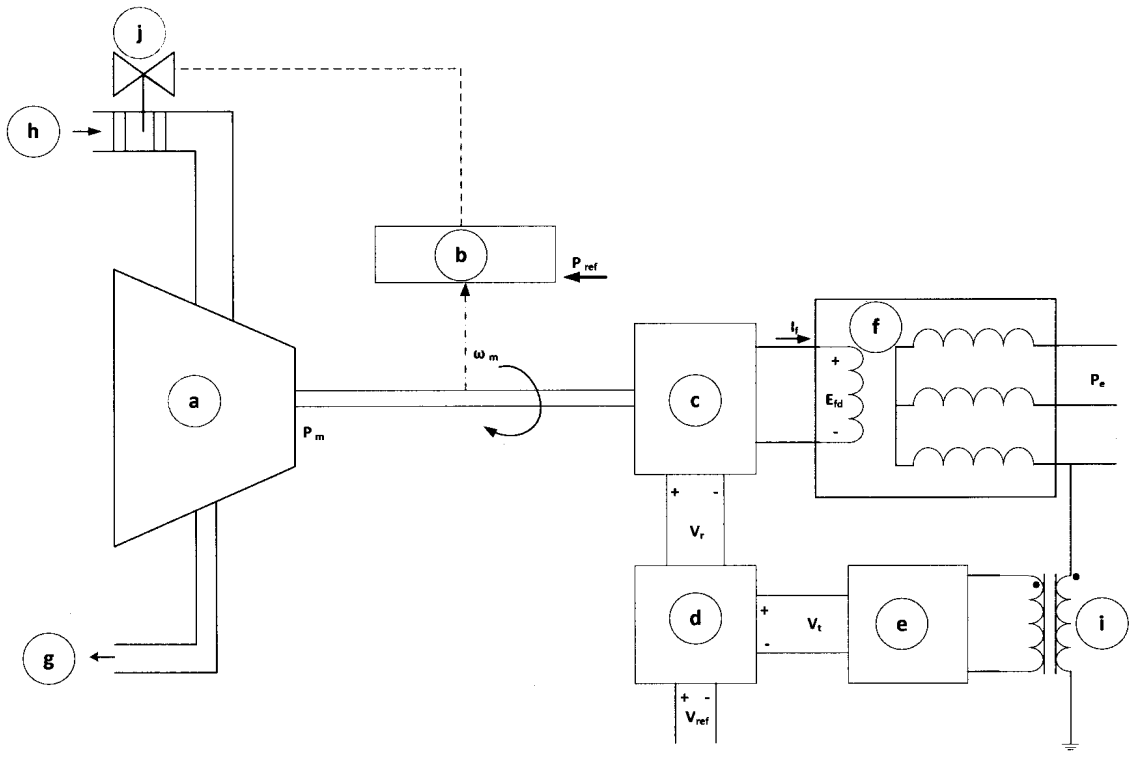

Figure 1: Voltage regulator and turbine-governor controls for a steam-turbines generator.

Question 2 [16 Marks]

(a) A single phase voltage source with $V = 240\angle 140^o$ volts has a current $I = 15\angle -60^o$ A which leaves 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. **[6]**

(ii) Identify the type of voltage source. **[1]**

(b) A synchronous generator may be represented by a voltage source of magnitude 1.7 p.u. in series with an impedance of 2 p.u. It is connected to a zero-impedance voltage source of 1 p.u. The ratio of X/R of the impedance is 10.

(i) Calculate the real power generated and the real power delivered to the voltage source if the angle between the voltage sources is 30^o **[7]**

(ii) Calculate the real power losses. **[2]**

Question 3 [16 Marks]

(a) Show how the scalar voltage difference between two nodes in a network is given approximately by: **[4]**

$$\Delta V = \frac{RP + XQ}{V}$$

(c) Each phase of a 50km, 132 kV overhead line has a series resistance of 0.156 Ω/km and inductive reactance of 0.4125 Ω/km. At the receiving end, the voltage is 132 kV with load of 100 MVA at power factor of 0.9 lagging.

(i) Calculate the magnitude of the sending end voltage. **[8]**
(ii) Calculate the approximate angular difference between the sending-end and receiving-end voltages. **[4]**

Question 4 [18 Marks]

(a) The daily demands of three consumers are given below:

Time	**Consumer 1**	**Consumer 2**	**Consumer 3**
12 midnight to 8:00 A.M.	No load	200 W	No load
8:00 A.M. to 2 P.M.	600 W	No load	200 W
2 P.M. to 4 P.M.	200 W	1000 W	1200 W
4 P.M. to 10 P.M.	800 W	No load	No load
10 P.M. to midnight	No load	200 W	200 W

(i) Plot the load curve. **[1.5]**
(ii) Find the maximum demand of individual consumer. **[1.5]**
(iii) Find the load factor **of** individual consumer **[3]**
(iv) Find the diversity factor. **[1]**
(v) Find the load factor of the station. **[1]**

(b) The equipment in a power station costs R 1560,000.00 and has a salvage value of R 60,000.00 at the end of 25 years. Determine the depreciated value of the equipment at the end of 20 years on the following methods:

(i) Straight line method. **[3]**
(ii) Diminishing value method. **[3]**
(iii) Sinking fund method at 5% compound interest annually. **[4]**