University of KwaZulu-Natal
Electrical, Electronic & Computer Engineering
Main Examination: November 2015

3 Hours Total Marks: Section 1 (50 Marks, Weight: 50); Section 2 (75 Marks, Weight: 50)

Examiners: Dr R. Tiako & Dr A. Saha (Internals)
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

[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 a three-phase overhead is R (200*a*+1000) per km length where '*a*' is the cross-sectional area of the conductor in sq mm. If the load is supplied 70% of the year, estimate the most economical current density for the conductor. The cost of energy is 150 cent per kWh and resistivity of conductor material is 1.8 μohm-cm. The rate of interest and depreciation per annum is 10%. **[12]**

QUESTION 2

A transmission line has a span of 200 m between level supports. The conductor diameter is 25 mm and it weighs 0.95 kgf/m while its material has a maximum tensile strength of 8000 kgf. The conductors are subjected to a radial ice-covering of 10.25 mm thickness and sag of 4.2 m. Calculate the horizontal wind pressure acting on the ice-covered projected area of the conductor if the factor of safety is 3.0 and weight density of ice is 913.5 kgf/m^3. **[10]**

QUESTION 3

A three-phase, 50 Hz overhead transmission line in shown in Figure 1. The diameter of each conductor is 50 mm while the radius of circumscribing circle is 1 m. Determine the inductance/ph/km of the transmission line. [**10**]

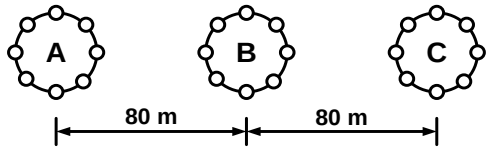

Fig. 1: Three-phase Transmission Line

QUESTION 4

The total charging kVA drawn by a three-phase underground cable when connected to three-phase, 50 Hz supply is 150 while the charging current is 7.5 A per conductor. The capacitance measured for the same cable between one core and the other two connected together to the sheath is 3.0 µF. Calculate (a) line-to-line supply voltage (b) equivalent capacitance of the cable (c) capacitance between any two cores of the cable (d) capacitance between a core and sheath [**9**]

QUESTION 5

A three-phase, 50 MVA, 11.5 kV star-connected generator has 3% reactance. Find the reactance in p.u. and 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. [**9**]

End of Section 1

Section 2

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

Part A: **[7 Marks]**

1. As a matter of economy, voltage for power transmission should be:
   (a) low, (b) medium, (c) high, (d) none of the above **[1]**

2. When transmission voltage is increased, the line losses are:
   (a) decreased, (b) increased, (c) the same, (d) none of the above **[1]**

3. The cheapest plant to operation and maintenance is:
   (a) steam power plant, (b) nuclear power plant, (c) hydroelectric plant, (d) diesel power plant **[1]**

4. Referring to the load curve in Fig. 1, units generated per day will be:
   (a) $12x10^5$ kWh (b) $6x10^6$ kWh (c) $7.5x10^5$ kWh (d) $8.5x10^5$ kWh **[2]**

5. A consumer has a maximum demand of 200 kW at 40 % load factor. If the tariff is R 100 Rands per kW of maximum demand plus 10 cents per kWh, the overall cost per kWh is
   (a) 8.42 cents, (b) 12.85 cents, (c) 19.25 cents, (d) 7.65 cents **[2]**

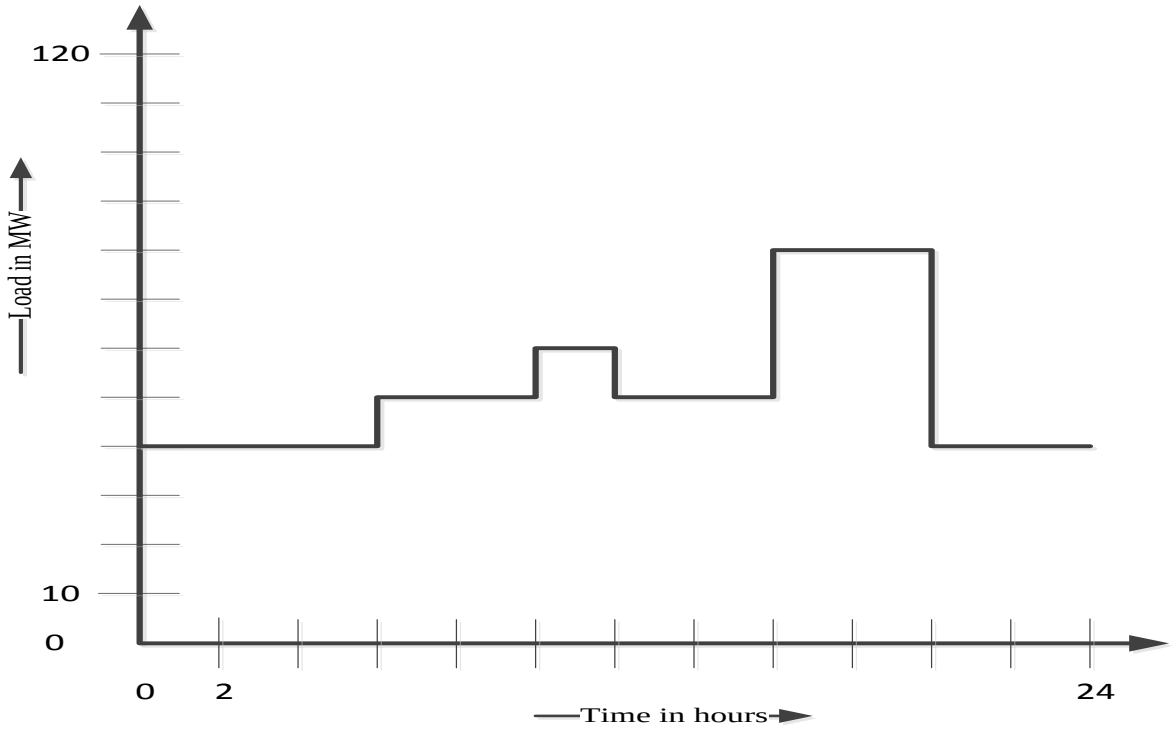

Figure 1: Load curve of a generating station

Part B: **[29 Marks]**

1. Explain the concept of power factor and discuss the various methods of power factor improvement. **[4]**

2. What are the objectives of power system control? **[4]**

3. Draw a block diagram of automatic voltage regulator and turbine-governor controls for a steam turbine generator. Discuss the functions of the different components of the control system. **[6]**

4. The load on a power plant on a typical day is as under:

Time	12 – 5 AM	5 – 9 AM	9 – 6 PM	6 – 10 PM	10 - 12 AM
Load (MW)	20	40	80	100	20

   Plot the load duration curve, find the load factor of the plant and the energy supplied by the plant in 24 hours. **[9]**

5. A consumer has a maximum demand of 100 kW. The p.f is 0.8 lagging and the load factor is 60 %. The tariff used is 75 Rands per kVA of maximum demand plus 15 Cents per kWh consumed. What will be the annual bill? **[6]**

Part C: **[39 Marks]**

C.1

A 100 kW installed capacity hydro-electric plant costs 3000 Rands per kW of installed capacity. The total annual charges consist of 15 % as interest; depreciation at 2 %, operation and maintenance at 2 % and insurance, rent etc. at 1.5 %.
Determine a suitable two part-tariff and the overall cost of generation if the losses in transmission and distribution are 0.125% and diversity of load is 1.25.Assume that maximum demand on the station is 80 % of the capacity and annual load factor is 40 %. **[18]**

C.2

A three phase line, which has an impedance of (2+j4) Ω per phase, feeds two balanced three-phase loads that are connected in parallel. One of the loads is Y-connected with an impedance of (30+j40) Ω per phase, and the other is Δ-connected with an impedance of (60-j45)Ω per phase. The line is energised at the sending end from a 60-Hz, three –phase, balanced voltage source of $120\sqrt{3}$ V (rms, line-to-line)

Determine the following:

(a) The current, real, and reactive power delivered by the sending end source. **[12]**
(b) The line-to-line voltage at the load. **[3]**
(c) The power losses **[6]**