UNIVERSITY OF SWAZILAND

MAIN EXAMINATION, SECOND SEMESTER

MAY 2017

FACULTY OF SCIENCE AND ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

TITLE OF PAPER: Fundamentals of Power Engineering

COURSE CODE: EE351

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. There are five questions in this paper. Answer any FOUR questions. Each question carries 25 marks.
2. If you think not enough data has been given in any question you may assume any reasonable values.

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THIS PAPER CONTAINS SIX (6) PAGES INCLUDING THIS PAGE

**QUESTION ONE** ***(25 marks)***

**(a)** A 480-V, 200-kVA, 0.8-power-factor-lagging 60-Hz two-pole Y-connected synchronous generator has a synchronous reactance of 0.25 Ω and an armature resistance of 0.03 Ω. At 60 Hz, its friction and windage losses are 6 kW, and its core losses are 4 kW. The field circuit has a dc voltage of 200 V, and the maximum field current $I_F$ is 10 A. The resistance of the field circuit is adjustable over the range from 20 to 200 Ω. The OCC of this generator is shown in **Figure Q 1**

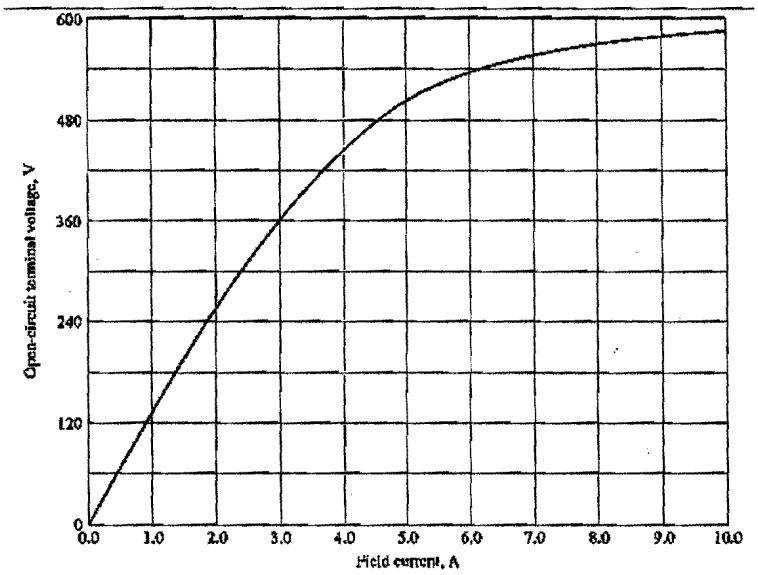


**Figure Q 1**

i. How much field current is required to make VT equal to 480 V when the generator is running at no load? [2]

ii. What is the internal generated voltage of this machine at rated conditions? [5]

iii. How much field current is required to make VT equal to 480 V when the generator is running at rated conditions? [2]

iv. How much power and torque must the generator's prime mover be capable of supplying? [6]

**(b)** A single phase motor connected to 240 V, 50 Hz supply takes 18 A at a power factor of 0.75 lagging. Calculate the reactive power required to increase the power factor to 0.95 lagging and the capacitance to provide this reactive power. [10]

**QUESTION TWO *(25 marks)***

(a) Draw a block diagram of power system and state the transmission and distribution voltages used in Swaziland. **[5]**

(b) An unbalanced, star-connected load is supplied from a 3-phase, 415 V source. The three phase loads are purely resistive. These loads are 45 Ω, 16Ω and 25 Ω, and are connected in the red, yellow and blue phases respectively. Determine the value of the neutral current, and its phase angle relative to the red phase current. **[10]**

(c) Explain :

i. Skin effect. **[2]**

ii. Ferranti effect. **[2]**

iii. Corona Effect and state two factors affecting it. **[3]**

iv. The elementary theory of Ideal Transformer. **[3]**

**QUESTION THREE** ***(25 marks)***

(a) Explain ring distribution system. State any two advantages of ring distribution system. **[7]**

(b) State any seven major equipment in substation. State function of each equipment **[7]**

(c) An industrial load takes 80 000 kWh per annum, the average power factor being 0.707 lagging. The recorded maximum demand is 500 kVA. The tariff is E120.00 per kVA of the maximum demand plus E0.25 per kWh.

(i) What type of tariff is described in (c)? **[1]**

(ii) Calculate the annual cost of supply? **[2]**

(iii) The annual savings in cost by installing a capacitor costing E 50.00 per kVar which raise the power factor to 0.9 lagging. Allow 10% per year cost of capacitor to cover additional costs. **[8]**

**QUESTION FOUR** ***(25 marks)***

(a) The single-phase, 50 km transmission line with resistance of 2.1 Ω and inductive reactance of 32.3 Ω is supplying 11 kV to an 800 kVA, power factor 0.9 lagging single-phase load.

(i) Draw the equivalent circuit of this transmission line. **[2]**

(ii) What is the sending end voltage and current of this transmission line? **[4]**

(iii) What is the efficiency of the transmission line under these conditions? **[2]**

(iv) What is the voltage regulation of the transmission line under these conditions? **[2]**

(b) A Steam power station spends E45 000 000.00 per annum for coal used in the station. The coal has a calorific value of 5000 kcal/kg and costs E 900.00 per ton. If the station has thermal efficiency of 33% and electrical efficiency of 90%. Find the average load on the station **[10]**

(c) Discuss the conditions that must be met before connecting a generator to the power grid. **[5]**

**QUESTION FIVE (25 *marks*)**

(a) With an aid of labelled diagrams. Explain how a spark gap lighting arrester protects substation equipment. **[10]**

(b) Draw the per-unit reactance diagram for the $3_{\Phi}$ shown in Figure Q5. Choose 100 MVA , 66 kV at the transmission line and 0.415 kV base for motor **[15]**

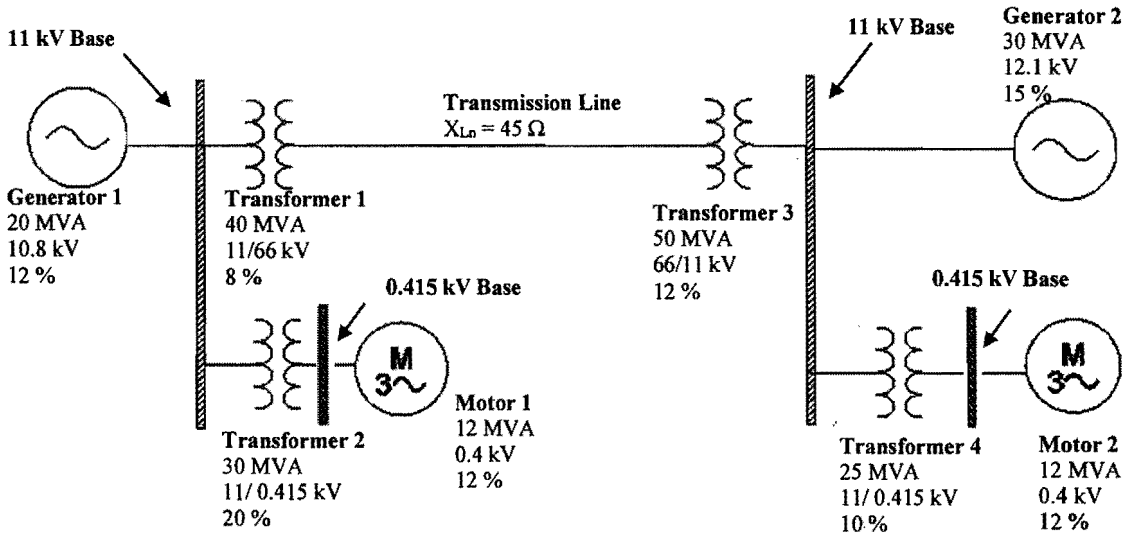


**Figure Q5**