University of KwaZulu-Natal

Electrical, Electronic & Computer Engineering Discipline

Main Examination: June 2014

DURATION: 2 HOURS **TOTAL MARKS: 75**

Examiners: Dr. R. Tiako (Internal)
Dr J. Van Coller (External)

Instructions: **Answer question 4 & any other 2 questions**

Question 1 [25 Marks]

A 240-kW, 240-V, 6-pole, 600 rpm separately excited DC generator is delivering the rated load at the rated voltage. The generator has an armature resistance, $R_a = 0.01\ \Omega$, a field voltage, $V_f = 120$ V, and a rotational loss, $P_r = 10$ kW. Determine:

(a) The induced EMF at full load. **[2.5]**
(b) The power developed. **[2]**
(c) The torque developed. **[2.5]**
(d) The applied torque. **[2.5]**
(e) From the magnetization curve given in Figure 1, it is seen that for the calculated induced EMF at full load, the obtained field current at full load is 2.5 A. This is the field current that must circulate in the field winding when there is no demagnetization effect of the armature reaction. By considering that the demagnetization MMF due to the armature reaction is 25 % of the armature current, calculate the total MMF that must be provided by the field winding and the actual field current at full load if the number of turns of the field winding, $N_f = 500$ turns per pole. **[7.5]**
(f) Calculate the efficiency. **[5.5]**
(g) Determine the voltage regulation. **[2.5]**

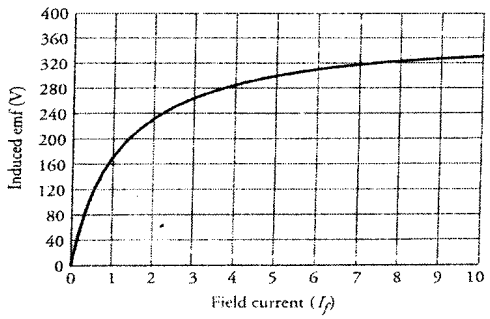

Figure 1: Magnetization curve for the DC machine at 600 rpm ($N_f = 500$ turns/pole)

Question 2 [25 Marks]

(a) A standard 480/120 V, 5 kVA two winding transformer is to be used as an auto transformer to supply power at 480 V from 600 V source. **[13.5]**
   (i) Draw the auto-transformer connection diagram and calculate various branch currents at full load.
   (ii) Determine its kVA capacity as the auto-transformer.
   (iii) Calculate the power transformed inductively and conductively.

(b) A 240-V shunt motor runs at 850 rpm when the armature current is 70 A. The armature circuit resistance is 0.10 Ω. Calculate the required resistance to be placed in series with the armature resistance to reduce the speed to 650 rpm when the armature current is then 50 A. **[7.5]**

(c) A 2400-V three phase bus supplies a three phase transformer which delivers a 600 kVA to a balanced three-phase 240-V resistive load. Assuming a Y-Y transformer, determine the primary and secondary line currents. **[4]**

Question 3 [25 Marks]

A simple power system is shown in Figure 2. This system contains a 380-V ($\mathbf{V_G} = 380\angle 0^o$) generator connected to an ideal 1:5 step-up transformer, a transmission line, and ideal 10:1 step down transformer, and a load. The impedance of the transmission line is 10 + j40 Ω, and the impedance of the load is $5\angle 10^o\,\Omega$. The base values for this system are chosen to be 380 V and 5 kVA at the generator.

(a) Find the base voltage, current, impedance, and apparent power at every point in the power system. **[11.5]**
(b) Convert and sketch this power system to its per-unit equivalent circuit. **[7]**
(c) Find the per-unit real and actual power losses in the transmission line. **[3.5]**
(d) Find the per-unit and actual reactive power losses in the transmission line. **[3]**

NB: In per-unit, please allow a minimum of 3 decimal digits for calculated values.

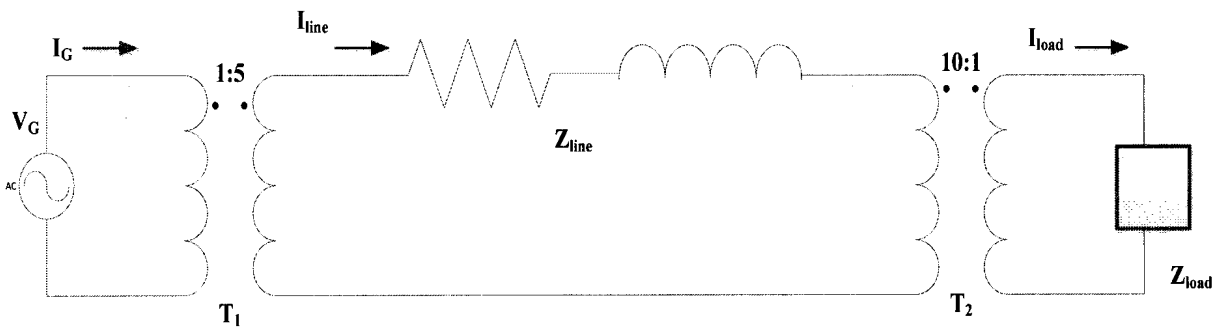

Figure 2. Power system of question 3

Question 4 [25 Marks]

A 460-V, 25-hp, 60-Hz, four-pole, Y-connected induction motor has the following impedance in ohms per phase referred to the stator circuit:

$R_1 = 0.641\ \Omega$ $R_2 = 0.332\ \Omega$ $X_M = 26.3\ \Omega$
$X_1 = 1.106\ \Omega$ $X_2 = 0.464\ \Omega$

The rotational losses are 1100 W and are assumed to be constant. The core loss is lumped in with the rotational losses. For a rotor slip of 2.2 percent at the rated voltage and rated frequency, find the following quantities:

(a) Draw the per-phase equivalent circuit of the induction motor. **[2]**
(b) The motor's speed. **[2.5]**
(c) The stator current. **[2.5]**
(d) The power factor. **[1.5]**
(e) The converted power, P_{con} and the output power in hp, P_{out}. **[10.5]**
(f) The induced torque, τ_{ind} and the load torque, τ_{load}. **[4]**
(g) The efficiency. **[2]**