The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX4548/ECX4248 -Electrical Machines**
Academic Year	: 2017/18
Date	: 31st January 2019
Time	: 0930-1230hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of **Eight (8)** questions in **Five (5)** pages.

3. Answer any **Five (5)** questions only. All questions carry equal marks.

4. Answer for each question should commence from a new page.

5. Relevant charts/ codes are provided.

6. This is a Closed Book Test (CBT).

7. Answers should be in clear hand writing.

8. Do not use Red colour pen.

Question 01

a) Briefly describe the type of losses in power transformers and explain the relevant test carried out to measure the losses. **[04 Marks]**

b) Discuss the applications of voltage transformer and current transformer **[02 Marks]**

c) An open circuit (OC) test and short circuit (SC) test were conducted on a transformer rated at 500 kVA, 69 kV/4.16 kV, 60 Hz. The following results were obtained from the two tests.

SC test	**V= 2600 V**	**I= 4 A**	**P=2400 W**
OC test	**V=4160 V**	**I=2 A**	**P= 5000 W**

   i. Determine the leakage reactance and winding resistance of the transformer, refereed to the HV side

   ii. Determine the values of magnetizing reactance (X_m) and core loss resistance (R_m)

   iii. Skech the equivalent circuit of the transformer referred to HV side and clearly indicate the parameters found in i,ii

   iv. Determine the efficiency of the transformer when a load of 250 kVA at 0.8 lagging power factor is connected

[14 Marks]

Question 02

a) The Group connection of a certain transformer is 31Dy -1. What does this term mean?

[3 Marks]

b) Figure Q2 shows the winding connections of a three phase transformer. Draw the phasor diagram to show the EMFs in windings and determine the phase shift between primary and secondary EMFs
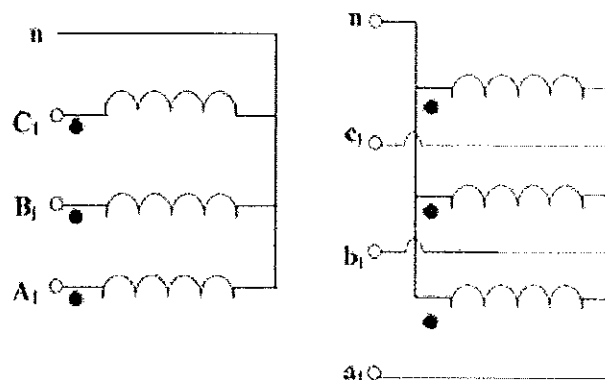

Figure Q2 **[5 Marks]**

c) Three single phase transformers rated each 100 kVA, 13.2 kV/ 2.4 kV are connected in star-delta to form a three-phase transformer. HV side of this three -phase transformer is then connected to a 18 kV three phase line.

    i.   what is the rating of three-phase transformer?

    ii.   determine the LV side line voltage?

[6 Marks]

d) A 100 kVA three phase, 50 Hz, 3300/400 V, delta-star connected transformer working at its full load efficiency at 95 % at 0.8 power factor lagging. The per-phase resistances of the high voltage and low voltage windings are 3.5 Ω and 0.02 Ω respectively. Calculate the iron losses of the transformer at normal voltage and frequency.   **[6 Marks]**

Question 03

a) What are the methods used to brake a DC motor? Briefly describe each of the method

[4 Marks]

b) What is the difference between dynamic braking and regenerative braking in an electric motor?   **[4 Marks]**

c) A 230 V DC shunt motor has armature and field resistance of 0.2 Ω and 230 Ω respectively. The motor's load torque $T_L \propto N^2$ and is running at 1000 rpm while drawing 10 A current from the supply. Calculate the new speed and armature current if an external resistance of 5 Ω is inserted to the armature circuit.   **[12 Marks]**

Note: Neglect armature reaction and saturation.

Question 04

a) Figure Q4 shows the characteristics curve of DC motor. Identify the type of motor and derive the expression for each characteristics from basic equations   **[4 Marks]**
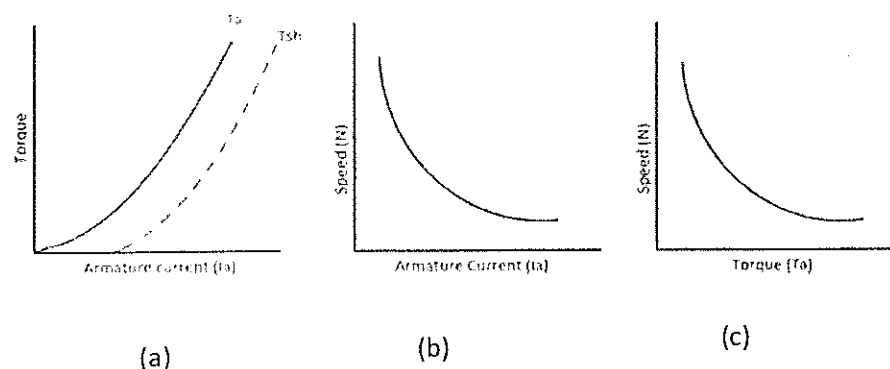

(a)   (b)   (c)

Figure Q4

2

b) A 230 V DC series motor has armature and field resistances of 0.15 Ω and 0.1 Ω respectively. It takes a current of 30 A from the supply while running at 1000 rpm. If a diverter resistance of 0.2 Ω is connected across the field coil of the motor, calculate the new steady state armature current and the speed. Assume that the load torque remains constant.

[16 Marks]

Question 05

a) Per phase equivalent circuit of a cylindrical rotor synchronous generator serving an inductive load is shown in figure Q5.
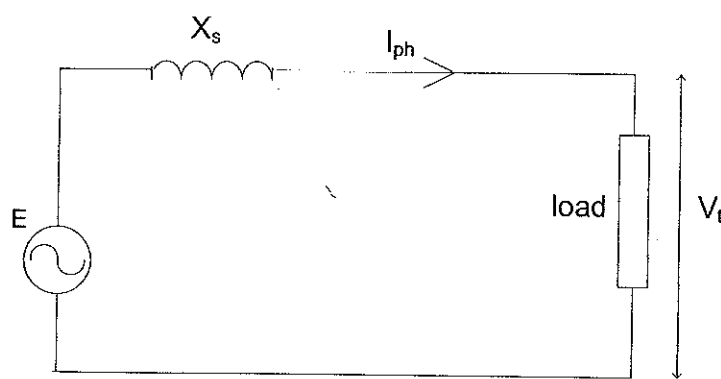

Figure Q5

  i.   Draw the phasor diagram for this situation.

  ii.   Derive an expression for the output power (P) for synchronous generator.

  iii. Draw the power-angle characteristic curve of the synchronous generator.

  iv. What are the limitations of generator output?

  v.   Derive expressions for each limitation given in part (iv).

b) Rating of the generator given in (a) are: 50 kVA rated at 0.8 power factor lagging, 400 V, 50 Hz. Per phase synchronous reactance is 1 Ω.This generator is connected to a steam turbine capable of supplying up to 45 kW. The synchronous generator friction and windage losses are 1.5 kW, and the core losses are 1.0 kW.

  i.   Calculate the limits of capability curve of synchronous generator and draw the capability curve indicating necessary values.

[20 Marks]

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Question 06

a) What is the purpose of an exciter in a generator? Explain the controlling of reactive power of the generator. **[4 Marks]**

b) A 2-pole, star connected synchronous generator rated at 300 kVA, 480 V, 60 Hz, and 0.85 power factor lagging. Its armature resistance is 0.04 Ω. The core losses of this generator at rated conditions are 10 kW and the friction and windage losses are 13 kW. The open-circuit and short-circuit characteristics are shown in Figure Q6.
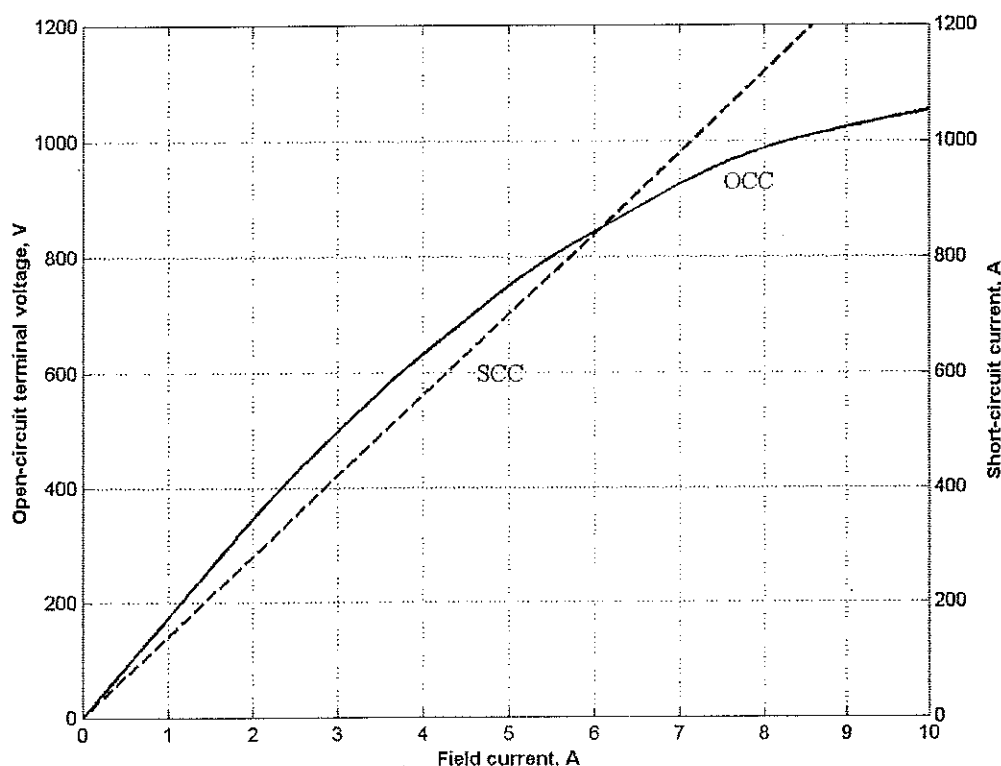

Figure Q6

a) Determine the saturated synchronous reactance of this generator at the rated conditions.

b) Determine the unsaturated synchronous reactance of this generator.

c) What are the rated current and internal generated voltage of this generator at the rated output?

d) What field current does this generator require to operate at the rated voltage, current, and power factor?

e) Calculate the voltage regulation of this generator at the rated current and power factor.

f) If this generator is operating at the rated conditions and the load is suddenly removed, what would be the terminal voltage? **[16 Marks]**

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Question 07

a) Compare DOL starting with Star-Delta starting method of an induction motor. [4 Marks]

b) Draw speed torque characteristics of wound rotor induction motor with different rotor resistance (R1>R2>R3). [3 Marks]

c) A 400 V, 4 pole, 50 Hz, three phase induction motor has a rotor resistance and reactance per phase of 0.01 Ω and 0.1 Ω respectively. Ratio of stator to rotor turns is 4.

Calculate:

    i. maximum torque and the corresponding slip

    ii. the full-load slip and power output, when the maximum torque is twice the full-load torque [12 Marks]

Question 08

a) State the merits and demerits of cage rotor induction motor compared with the wound rotor induction motor. [4 Marks]

b) A three phase delta connected 4000 V, 60 Hz squirrel cage induction motor draws a current of 385 A and a total active power of 2345 kW when operating at full load. The corresponding speed is accurately measured and found to be 709 rpm. The resistance between two stator terminals is 0.1 Ω. The total iron loss is 23.4 kW and the windage and friction loss is 12 kW.

Calculate:

    i. the power factor at full load

    ii. the active power supplied to the rotor

    iii. total copper losses in the rotor

    iv. the mechanical power developed

    v. torque at the load

    vi. efficiency of the motor

[16 Marks]