THE OPEN UNIVERSITY OF SRI LANKA
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
DIPLOMA IN TECHNOLOGY

ECD2207 - ELECTRICAL MACHINES

FINAL EXAMINATION –2005/2006

Date: 10th April 2006 **Time: 0930 - 1230 hrs**

This paper contains seven questions and answer any **five (5)**. All questions carry equal marks.

Q1. Three phase 230 V, 50 Hz induction motor is to be fed from a 4000 V ac supply using a three-phase step down transformer. The electrical power required by the motor is 150 kVA at 0.85 power factor lagging.

(i). If three single-phase 60 kVA transformers are used to perform this task what should be the primary and secondary winding connection? Illustrate this using schematic diagram.

(ii). Equivalent series impedance of the each transformer referred to the low voltage side is 0.012+j0.016 Ω. Calculate the winding (LV & HV) currents of the transformer.

(iii). If secondary side voltage is 230 V, calculate the primary side voltage and voltage regulation.

Q2.(a). With the help of sketches, explain and compare the following construction features of:

(i). Shell-type and core –type of transformers.

(ii). Cylindrical and sandwich windings.

(b). A single phase 230 V/2300 V transformer is rated at 10 kVA. These two windings are electrically connected together in series (so that their voltage are additive) and form an autotransformer providing that the low voltage remains unchanged .

(i). What are the rated input and output currents before forming autotransformer ?

(ii). Calculate the transformation ratio, input and output currents of autotransformer.

(iii). Determine the increment of rating after forming autotransformer.

(iv). If the efficiency of the two winding transformer is 0.98 at rated power and 0.9 power factor lagging what would be the efficiency after connecting windings (power factor remain unchanged)?

Q3. (a). With the help of a suitable circuit diagrams, explain the star delta method of starting an induction motor.

(b). Determine the relationship between direct starting torque and delta to star starting torque. Prove same for currents.

(c). A certain three phase induction motor has the following rated values:
P=315 kW; N= 1485 rpm, η=94.5%, Cosφ=0.91, V=220 volts
When this machine is subjected to a direct starting the ratio of starting torque to nominal is 1.1 and that for the current is 7. If this motor is started using star to delta method determine the starting current and starting torque. Is it possible to start this machine with 25% of full loading?

Q4. A three phase four pole 50 Hz induction motor is subjected to an open circuit and locked rotor tests and parameters were determined using the measurement obtained. The parameters are :
R_1=0.11 Ω; R'_2 =0.08 Ω; X_1=0.4 Ω; X'_2 = 0.35 Ω; X_m=10 Ω
Line current during the locked rotor test is 80 A and no-load test done at synchronous speed.

(i). What is the input voltage at locked rotor test?
(ii). Calculate the power consumed by the machine at no-load test.
(iii). If the speed of the motor at rated speed is 1465 rpm, calculate the rated power, rotor loss and maximum torque.

Q5. A three-phase cylindrical rotor synchronous machine has following nominal parameters:
V_{line} =660 V; S=200 kVA; Cosφ=0.8; f=50 Hz

When the generator delivers nominal active power at *unity* power factor, power angle is 50^0. The field current at this situation is 72 A.

(i). Determine the synchronous reactance and emf of the generator. If saturation is neglected what is the field current at no-load condition?
(ii). Calculate the power angle when machine is operating at the nominal mode of operation.
(iii). If this machine is operating at '*underexcited*' condition with 0.9 power factor what would be the voltage behind the transient reactance.

Q6. Two generators G1 and G2 are operating in parallel to share a load of 40 MW at 0.8 power factor lagging. The output voltage of the generators are maintained at 13 kV. Synchronous impedance of G1 and G2 are 0.1+j1.0 Ω and 0.2+j1.5 Ω respectively. If both generators deliver equal reactive power and current of the first generator is 1250 A, Find:
(i). Active and reactive powers delivered by each generator.
(ii). Current through the second generator.
(iii). Power angles of the generators G1 and G2.
(iv). Draw the phasor diagram to illustrate emf and currents of G1 and G2. (Consider terminal voltage as reference)

Q7. (a). Explain 'sub-transient reactance ' and 'transient reactance' of synchronous generator.

(b). Two generators A and B have following data:

	Generator A	Generator B
Rated power	150 MW	250 MW
No-load frequency	51 Hz	52 Hz
Speed drop from no-load to rated load	4 %	5 %

If these two generators are operating in parallel and share a common load of 300 MW calculate

(i). Common frequency at load

(ii). Output power of each generator.