BITS, PILANI – DUBAI CAMPUS
FIRST SEMESTER 2013 – 2014
EEE/INSTR/ ECE F211 ELECTRICAL MACHINES
COMPREHENSIVE EXAMINATION (CLOSED BOOK)

MAXIMUM MARKS: 60 WEIGHTAGE: 30 %
DATE: 29.12.13 DURATION: 3 hours

NOTE: 1) Attempt PART A and PART B in separate booklets.
2) Attempt all parts of a question sequentially.
3) If a question is answered twice and not cancelled, only the first attempt will be evaluated.
4) Show calculations stepwise.
5) Sketches/ diagrams/ graphs are to be complete.

PART A

1. A small industrial unit, considered as a balanced 3 phase load, draws power from the secondaries of a 2000/200 V, 60 kVA Δ/Δ transformer bank. [8M]
   Find:
   1A) Rated line current available from the transformer bank
   1B) Rated phase current of the Δ-secondaries
   1C) Primary phase current
   1D) Primary line current

2. The efficiency of a 1000KVA, 110/220 V 50 Hz single phase transformer is 98.5 % at half full load at 0.8 power factor lead and 98.8% at full load unity power factor. Determine
   (2A) Iron loss
   (2B) Full load copper loss [4+4 M]

3. A 4 pole, 240 V, wave connected shunt motor gives useful output 11.19 kW when running at 1000 rpm and drawing armature and field current of 50 A and 1 A respectively. The armature has 540 conductors and 0.1 Ω resistance. Calculate
   (3A) Gross torque
   (3B) Useful torque
   (3C) Flux/pole
   (3D) Motor efficiency [2+2+2+2 Marks]

4. With respect to dc shunt motor, answer the following: [6 M]
   (4A) Draw the speed-torque characteristics for fixed field current
   (4B) Mention the effect of armature reaction on the above characteristics.
   (4C) Draw the speed control characteristic for armature control method

PART B

5) A 250 V dc shunt motor takes 16 A when running light at 1440 rpm. The armature resistance of the machine = 0.2 Ω. Field resistance is 125 Ω. Calculate Efficiency of the machine

5A) As a generator delivering a load current of 152 A at 250 V.
5B) As a motor taking a line current of 152 A at 250 V. **[10 M]**

6) The following data are taken from the open-circuit and short-circuit characteristics of a 45-kVA, three-phase, Y-connected, 220-V (line-to-line), six-pole, 60-Hz synchronous generator. **[10M]**

From the open-circuit characteristic:
Line-to-line voltage = 220 V ; Field current = 2.84 A
From the short-circuit characteristic:

Armature current (A)	118	152
Field current (A)	2.20	2.84

From the air-gap line:
Field current = 2.20 A; Line-to-line voltage = 202 V

Determine
6A) the speed of rotation
6B) the unsaturated synchronous reactance
6C) the adjusted synchronous reactance
6D) the excitation voltage needed to give rated voltage at full load, 0.8 pf lagging. Use adjusted synchronous reactance.
6E) voltage regulation for load specified in question 6D.

7) Draw the complete torque-slip characteristics of a 3-phase induction motor and clearly state its various modes of operation along with corresponding range of slip values. **[5M]**

8) A 6 pole, 50 Hz, 3 phase induction motor runs at 960 rpm on full load with a rotor current per phase of 35 A. If the mechanical power developed by rotor is 19.65 kW, find the resistance per phase of 3 phase rotor winding. **[5M]**

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TEST 2 (OPEN BOOK)

MAXIMUM MARKS: 20 WEIGHTAGE: 10%
DATE: 21.11.2013 DURATION: 50 MINUTES

NOTE: 1) Only prescribed text book and hand written notes permitted
2) Attempt all parts of a question sequentially.
3) If a question is answered twice and not cancelled, only the first attempt will be evaluated.
4) Show calculations stepwise.

1. A 14.92 kW, 230 V, 1150 rpm, 4 pole, DC shunt motor has a total 620 conductors arranged in 2 parallel paths and yielding an armature circuit resistance of 0.2 Ω. When it delivers rated power at rated speed, it draws a line current of 74.8 A and a field current of 3 A. Calculate the following: [1+1+2+2+4 M]

   (1A) Flux per pole
   (1B) The torque developed
   (1C) The rotational losses
   (1D) Efficiency
   (1E) Maximum Efficiency

2. A 4 pole, DC shunt generator with a shunt field resistance of 100 Ω and an armature resistance of 1 Ω has 378 wave-connected conductors in its armature. The flux per pole is 0.02 Wb. If the load current is 22.7 A and the generator is driven at 1000 rpm, Calculate the following: [7+3 M]

   (2A) Output power delivered by the generator to the load.
   (2B) If the machine is now operated as a motor at the same terminal voltage with an armature current of 25 A, calculate the motor speed. Assume that the flux per pole is made to decrease by 10 % as the operation is changed over from generator to motor.

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TEST 1 (CLOSED BOOK)

MAXIMUM MARKS: 30 WEIGHTAGE: 15%
DATE: 26.09.2013 DURATION: 50 MINUTES

NOTE: 1) Attempt all parts of a question sequentially.
2) If a question is answered twice and not cancelled, only the first attempt will be evaluated.
3) Show calculations stepwise.
4) Sketches/ diagrams are to be complete in all respect.

1. A 20 kVA, 50HZ, 2000/200 V single phase distribution transformer gave the following data on OC and SC test.
   OC test (HV-Open circuit) : 200 V, 4A, 120W
   SC test (LV-Short circuit) : 60 V, 10A, 300W
   1A) Find the series and shunt parameters of the above transformer. [3M]
   1B) Draw the equivalent circuit of the above transformer referred to HV and LV sides. Label all the parameters. [4M]
   1C) Calculate the efficiency of the above transformer at half load 0.8 power factor lag. [5M]
   1D) Find the magnetizing current (I_m) and iron loss component current (I_i) and no-load power factor [3M]

2. The resistances and leakage reactances of a single phase, 150 kVA, 50 Hz, 2400 / 240 V transformer are as follows:

   R1 = 0.2 Ω R2= 2 x 10^{-3} Ω X1= 0.45 Ω X2= 4.5 x 10^{-3} Ω

   2A) Consider the transformer to give its rated kVA at a power factor (pf) of unity to a load at rated voltage. Find the HV terminal voltage and its percentage regulation.
   2B) Repeat the above problem for a load pf of 0.8 leading.
   2C) Find the load pf corresponding to zero voltage regulation.
   2D) Determine the load pf (lagging) at which maximum voltage regulation occurs.
   2E) If the load in question 2A gets short circuited by a fault, find the steady-state current in the HV lines, assuming that the voltage applied to the transformer remains unchanged. [6+3+2+2+2 M]
