Birla Institute of Technology and Science, Pilani

Semester-I, 2016-17

Comprehensive Examination (Close Book)

Course No. : EEE/INSTR F211 (Electrical Machines)

Date: 12-12-2016 **Max. Time - 180 Min.** **Marks -105**

Name	**ID. No.**	**Sec.-**

Instructions: Question Paper is in 2-Parts **A & B**. Part **A**, has to be answered in Question paper itself. Overwritten / cutting answers will not be evaluated.

PART – A

Marks –[1x35=35] **Max. Time – 60 Min.**

Q.1. A balanced star connected load of 21 kW takes a leading current of 50 A when connected to a three phase 415 V, 50 Hz supply. The per phase load resistance is_____Ω and reactance is _____ Ω.

Q.2. KVA demand of an industrial plant is 200 kVA at 0.8 lagging pf. The kVAR rating of capacitor bank required to reduce kVA demand to 180 kVA is _____and new power factor is _____lagging.

Q.3. Two transformers are required for a Scott connection operating from a 415 V, 3-phase supply for supplying two single phase furnaces at 250 V on the two phase side. If the total output is 15 KVA, The current in secondary winding is _____ A, and secondary to primary turns ratio is _____.

Q.4. A single phase, 100MVA, 200/80 kV transformer has the following test data:

Open circuit (HV): 200kV 20A, 10kW

Short circuit (HV): 30kV, 500A, 500kW

Values of $\mathbf{R_{eq}}$ and $\mathbf{X_m}$ (referring to HV side) are _____ Ω and _____ Ω respectively.

Q.5. A six pole alternator is generating power at 210 V per phase while running at 1500 rpm. If the speed of the alternator drops to 1000 rpm, the generated voltage per phase will be _____V and electrical degrees passed through in one revolution is _____.

Q.6. A 3-phase, star connected alternator rated for 400V operation, the per phase resistance and synchronous reactance are 0.15 Ω and 9 Ω respectively. The excitation emf. (line-line), and load angle for the alternator when it is delivering 9 A at UPF are _____V and _____degree respectively.

Q.7. The air gap power in a 3 phase induction machine is 10 kW and the slip is 2%. The rotor copper loss and the gross mechanical power output are_____W and _____kW respectively.

Q.8. A 1/3 hp, 50 Hz, 4 pole, single phase induction motor is running at speed of 1455 rpm. The value of the forward slip is _____% and the backward slip is _____%.

Q.9. A 60 hp, 230 V, DC shunt motor has armature resistance of 0.25 Ω and field resistance of 23 Ω. The no load speed of the motor is 1200 rpm. The induced back emf is _____ V and the speed _____rpm when the motor is drawing 75 A current from the supply.

Q.10. A 6-pole Lap wound DC machine armature has numbers of parallel paths A =_____ and wave wound armature has numbers of parallel paths A = _____.

Q.11. A single-phase, 230 V, 50 Hz, 4-pole, capacitor start induction motor has the following stand still impedances: Main winding impedance Z_m = 6+j4 Ω, Auxiliary winding impedance Z_a = 8+j6 Ω. The value of capacitor required to produce 90° phase difference between currents in main and auxiliary windings is _____μF and the current in main Winding is _____A.

State True & False.(write "**T**" for True & "**F**" for False)

(i) In a unbalanced 3-phase 4-wire system the, neutral wire carries zero current. ( )

(ii) Pure inductor and capacitor does not consume any real Power. ( )

(iii) Short pitch coil has winding factor always unity. ( )

(iv) Open Delta transformer can feed 57.7% of rated load. ( )

(v) For Transformers operating in parallel, voltage magnitude may not be the same. ( )

(vi) In a electro magnetic ckt. with air gap, the most of energy is stored in air gap. ( )

(vii) In non-linear magnetic ckt. The energy & co- energy are equal. ( )

(viii) The short pitch angle for eliminating 5^{th} harmonic is 25 degree. ( )

(ix) Capacitor-run type of single-phase ind. motor has high power factor at full load. ( )

(x) High resistance rotor in a single-phase ind. motor gives high acceleration. ( )

(xi) The Torque/power angle of a synchronous motor is always positive. ( )

(xii) The Torque speed characteristics of DC shunt motor resembles with Ind. Motor. ( )

(xiii) The speed of DC series motor at no load is infinitely high. ( )

PART – B

Max. Time - 120 Min. **Max.Marks – 70**

Instruction: 1-Solution must be to the point, neat and clean, showing all major steps for full credit.
2- Attempt all parts of question together.

Q.1.a. Show that VA rating of an Auto-Transformer is greater than VA rating Two winding transformer (without exceeding the nominal current in the windings).

Q.1.b. A 50 kVA, 50Hz, 11000 / 2200 V two winding transformer is connected to make a Step-Up auto-transformer, what will be the voltage ratio and the kVA output for the best possible option?

[10]

Q.2.a. Derive that in a 3-phase Induction Motor, the value of maximum torque (T_{Max} or T_{BR}) is independent of rotor circuit resistance. Draw the torque–speed characteristics for different rotor circuit resistances. (Assume the stator impedance negligible)

Q.2.b. A 4 pole, 50 Hz, 3 Phase induction motor develops a maximum torque of 110 Nm at 1360 rpm. The resistance of the star connected rotor is 0.25 ohm/phase. Calculate the value of resistance that must be inserted in series with each rotor phase to produce a starting torque equal to half of the maximum torque. (Assume the stator impedance negligible)

[10+10]

Q.3.a. Derive the relationship for three-phase power developed by the synchronous machine in terms of terminal voltage, excitation emf. reactance and torque angle. Draw the labeled power vs torque angle characteristics. (Assume stator resistance negligible)

Q.3.b. A 6.6 kV, 50Hz star connected 3 phase synchronous generator, having a per-phase synchronous reactance of 9.5 ohm, operates on 6.6kV infinite bus bars (infinite bus bars: supply point with practically constant voltage and frequency level) with the field current set to produce excitation emf of 1.1 pu (pu: per unit. The per-unit value of any quantity states it as a multiple of the rated value. Thus 1.1 pu emf = 1.1 x 6.6 kV emf). Calculate the maximum power that this generator can feed to the bus bars, and the power factor at which it will do so.

[10+10]

Q.4.a. Draw the flux waveform around the air-gap, flux waveform passing through the coil and induced emf in the coil, for a 4-pole DC machine rotating with constant speed,. Explain the significance of back emf in motor. (Assume the flux per pole φ_p)

Q.4.b. A load requiring 4Nm at 25 rev/sec is to be driven by a DC series motor, operating on an available supply of 200V. A test on this machine at standstill shows that torque of 4 Nm can be produced by a 10 V supply, the terminal current being 5 A. The rotational losses for the machine are negligible. What value of resistance, in series with the 200 V supply, will meet the rated condition?

[10+10]

A 115 V, 4-pole 60 Hz, single phase Induction Motor is rotating clock wise at a speed of 1710 rpm. Determine it's per unit slip. (i) in the direction of rotation (b) in the opposite direction. If the rotor resistance at standstill is 12.5 Ω. Determine the effective rotor resistance in each branch.

Explain the different mode of operation (e.g. Over excitation, under excitation, & upf) with the help of current – voltage phasors for the constant power operation with the variable excitation when the machine is acting as a generator. Draw the labeled V-curves

Explain the significance of Voltage Regulation of a Transformer. Derive the relation for the voltage regulation in terms of per unit quantities of circuit parameters, at laging p.f of load.