Ref. No. Ex/PE/PC/B/T/216/2025

Bachelor of Power Engineering 2nd Semester 1st Semester Examination 2025

Subject Electrical Generators and Transformers

Time 3 Hours | Use separate answer scripts for each Part | Full Marks 100

Part – I (70 marks)

1. Answer any **Six** (CO1) 6x 1 = 06

a) What is dielectric loss for a transformer insulation??

b) State three differences between shell type and core type 3 phase transformers?

c) Why air gap in DC generators should be very small?

d) Why for a single phase transformer the L V. winding is placed closer to the core?

e) What is a radiator for a transformer?

f) What is sludging of transformer oil?

.g) What is the Core material of a big DC Generator?

h) What are the general materials by which commutator are made for DC Generator?

i) State whether thin or thick wire should be used for shunt field of dc Generator?

j) What is the different types of Transformer winding??

k)What are the different Cooling methods of a Big Transformer?

2. Answer any **Two** (CO2) 2 x 2 = 04

i) Define Per Unit Values

ii) Define Critical Resistance of a DC Generator

iii) Define Voltage Build up process of a DC Generator

iv) Define All Day Efficiency

v) Define In rush Phenomenon in a Transformer

3. Answer any **Five** (CO3) 2x 5 = 10

i) How Swinburn Test can provide the efficiency of a DC Machine?

ii) Explain the Conducted VA and Transformed VA for an Auto Transformer

iii) Estimate the Utilization factor of Open Delta transformer

iv) Explain Armature Reaction in case of a DC Generator.

v) Explain why vector groups are important for Parallel Operation of 3 Phase Transformer

[Turn over

v)Explain the Circuit diagram of a Scott Connected Transformer

vi) Explain the process of commutation in DCGenerator?

vii) How harmonics are suppressed in a three phase Transformer?

4. Answer any **Two** (CO4) 2x2 =4

a. Draw the equivalent Circuit of a 1 Phase Transformer

b.Name the Two Tests where form Equivalent Circuit parameters of a 3 Phase Transformer can be obtained

c. Draw the equivalent Circuit of a 3 Winding Transformer

d. Show that a Transformer is basically an Inductance.

5. Answer any **Five**(CO5) 2x 5 = 10

i)Derive to show Scott Connection can be used for Three phase to Two Phase Conversion and vice versa

ii)Derive the formula for De-magnetising Ampere Turns for aDC Generator

iii) Derive the Expression of Induced EMF of a Single phase Transformer

iv)Derive Condition of Maximum Efficiency of a 1 Phase Transformer

v)Derive the phasor diagram from the circuitfor any two of the following 3 phase transformer connections:

Dd1, Dy11,Yz6. Dz11

vi)Explainunbalance operation and Oscillating neutral for a three-phase transformer.
vii) Derive the Condition of Maximum Voltage Regulation for a 1 phase Transformer

5. Answer any **Six**(CO6)(Choose 1 question between question i and ii(DC Generator), Choose 3questions between question iii and viii (Three Phase Transformer), and Choose 2 questions between ix and xii(Single Phase Transformer))6x 6 =36

i) A 1500kW, 600V, 14-pole DC machine has a lap wound armature with 1200 conductors. The pole arc to pole-pitch ratio is 0.75. Compute the number of pole-face conductors of the compensating winding in each pole, so as to obtain uniform air-gap flux density under the pole faces

ii) A 8-pole D.C shunt generator with 778 wave-connected armature conductors and running at 500 r.p.m. supplies a load of 14.5Ω resistance at terminal voltage of 250 V. The armature resistance is 0.30Ω and the field resistance is 300Ω. Find the armature current, the induced e.m.f and the flux per pole?

iii)Three similar single phase transformers have the primary and secondary windings connected in star and the tertiary windings connected in delta. In each transformer, the secondary and the tertiary turns are equal while the ratio of primary to secondary is 2. A single phase load taking 35A at 0.85 p.f is connected between one line and neutral of the secondary. Calculate the currents in each winding of the transformer.

iv) A Scott connected Transformer set supplies two 1-phase furnace A and B each at 220 V from a 3-phase 6.6 kV system. If the furnace connected to teaser transformer takes 350kW at upf and the other connected to main transformer takes 480kW of 0.85pf lag, Determine the line currents taken from the supply mains. Neglect losses and magnetizing current.

v) Two transformers connected in star-delta and delta-star configurations. The transformers are operating in parallel to supply a balanced load in a power system.
Transformer 1 (T1): Rated Power: 100 kVA, Primary Voltage: 11 kV (line-to-line), star connected, Secondary Voltage: 415 V (line-to-line), delta connected, Impedance (per-phase): Z1=(0.4+j0.6)□Ω
Transformer 2 (T2): Rated Power: 50 kVA, Primary Voltage: 11 kV (line-to-line), delta connected, Secondary Voltage: 415 V (line-to-line), star connected, Impedance (per-phase): Z2=(0.5+j0.75)□Ω
The two transformers are connected in parallel to supply a balanced three-phase load. The load is 130 kW with a power factor of 0.9 lagging. Find: (i) The total apparent power required by the load. (ii) The phase displacement between the primary and secondary sides of each transformer.

vi) Given: Transformer 1 (T1): Rated power: 75 kVA, Primary voltage: 11 kV (line-to-line), Secondary voltage: 400 V (line-to-line), Impedance: Z1=(0.5+j0.75)□Ω(per-phase). Transformer 2 (T2): Rated power: 50 kVA, Primary voltage: 11 kV (line-to-line),Secondary voltage: 400 V (line-to-line), Impedance: Z2=(0.6+j0.9)□Ω (per-phase). The two transformers are connected in an open delta configuration. A balanced three-phase load of 90 kW with a power factor of 0.8 lagging is connected to the secondary side. Find: the total apparent power of the load, the load sharing between the two transformers

vii) A three phase transformer is rated for 125 kVA with a primary Voltage of 11 kV (line-to-line) and a secondary Voltage of 415 V (line-to-line). The impedance is (0.25+j0.35)□Ω (per-phase). A single-phase Load with real power of 12 kW and power factor of 0.85 lagging is connected to Phase A of the secondary side (with Phases B and C unloaded). Find: Total apparent power of the load, Current supplied by the transformer on Phase A (secondary side),

viii) A three phase step down transformer energized from 11kV, 50Hz source takes a line current of 50A from the supply mains. Calculate the output voltage, output current and output kVA for any two of the following connections: a) delta/delta; b) delta/zigzag.

ix)The maximum efficiency of a 40KVA, 50Hz, 1100/415V single-phase transformer is 97% and occurs at 85% of full load at unity power factor. If the impedance is 6%, calculate regulation at full-load 0.9 power factor lagging.

x) A 800 kVA rated transformer has following specifications:

Primary Voltage: 33 kV (line-to-line), star connected
Secondary Voltage: 415 V (line-to-line), delta connected
Core Loss (per-phase): 600 W
Impedance (per-phase): Z=(0.4+j1.2) Ω
Load Condition: The transformer operates under 70% of its full load.
Load Power Factor: 0.9 lagging
Frequency: 50 Hz
Magnetic Flux Density: B=1.2 Tesla
The transformer is under a partial load of 70%, find the following:

a. Total core loss at 70% load.
b. Copper losses at 70% load.

xi) The resistances and leakage reactances of a 40-kVA, 50-Hz, 2400-V:240-V 1 Phase distribution transformer are
$R_1 = 0.8\ \Omega$; $R_2 = 0.0070\ \Omega$; $X_{l1} = 7.8\ \Omega$; $X_{l2} = 0.0780\ \Omega$

where subscript 1 denotes the 2400-V winding and subscript 2 denotes the 240-V winding. Each quantity is referred to its own side of the transformer.

a. Draw the equivalent circuit referred to (i) the high-voltage side. Label the impedances numerically.

b. Consider the transformer to deliver its rated kVA to a load on the low-voltage side with 220 V across the load. (i) Find the high-side terminal voltage for a load power factor of 0.80 lagging.

xii) A single-phase autotransformer is connected to a 220 V supply. The autotransformer supplies two loads: one with a resistive load of 5 kW at 220 V and another with a capacitive load of 2 kVAR at 220 V. The autotransformer voltage ratio is 2:1, meaning the secondary voltage is 110 V. The internal impedance of the autotransformer is Zauto=0.5 Ω. Find: (i) The current drawn from the supply. (ii) The total power delivered to the load

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B.E. POWER ENGINEERING SECOND YEAR FIRST SEMESTER - 2025
ELECTRICAL GENERATORS AND TRANSFORMERS

Time: Three hours Full Marks: 100

Part-II (30 marks)
(Use Separate Answer scripts for each part)

Q1. Answer any two questions: (CO1) 2×3

(a) An open circuit characteristic of a synchronous machine has a curved shape.
(b) Show that the armature reaction effect in an alternator has a demagnetizing effect while supplying a lagging power factor load.
(c) The large synchronous machines have the field winding on the rotor and the armature winding on the stator. - Justify.
(d) Discuss how the terminal voltage of an isolated synchronous generator changes as it supplies its own load

Q2. Define any two terms: (CO2) 2×2

Winding factor, Synchronizing Torque, Synchronous Reactance, Hunting

Q3. Answer any one question: (CO3) 1×3

(a) "At the time of synchronizing, frequency of the incoming machine should be slightly higher than that of the infinite bus." Justify this statement.
(b) Show that, for a synchronous generator working at leading pf $\cos\theta$,

$$tan\varphi = \frac{V_t \sin\theta - I_a X_q}{V_t \cos\theta + I_a X_q}$$

where φ is the angle between I_a and E_f phasors.
(c) For a cylindrical rotor alternator working at at lagging power factor, show that

$$\tan\delta = \frac{I_a\left(X_s\cos\theta - r_a\sin\theta\right)}{V_t + I_a\left(X_s\sin\theta + r_a\cos\theta\right)}.$$

Q4. Answer any one question: (CO5) 1×3

(a) Develop the voltage phasor equation of a salient pole alternator working at leading pf load.
(b) Develop the power expression of cylindrical rotor alternator.
(c) How can a Synchroscope be used for synchronising an incoming alternator with an infinite busbar?

Q5. Answer two questions: (CO6) 7×2

(a) The open circuit characteristic of a 6-pole, 440 V, 50 Hz, star connected alternator is as given below:

Field current(A)	2	4	6	7	8	10	12	14
Terminal voltage on open circuit(V)	156	288	396	440	474	530	568	592

A field current of 7 A is needed to circulate the full load rated armature current of 40 A under short-circuit condition. The armature resistance is 0.3 ohms per phase. Find the voltage regulation at full-load current of 40 A at 0.7 lagging power factor.
(b) Find the line value and the rms value of the voltage developed in a three phase, 50 Hz, 20 poles, 180 slots synchronous generator having a single layer winding with full pitch coils, the coils being connected in 60° phase groups, each coil having 6 turns. All the coils of a phase are in series.
(c) A 2 MVA, 6 kV, 8 pole, 3-phase, 50 Hz, alternator having synchronous impedance of 25% is synchronized to 6 kV bus. Find the synchronizing power per mechanical degree of angular displacement at full load 0.8 power factor lagging and at the rated voltage. Also find synchronizing torque for a 0.5° mechanical displacement.
(d) A salient pole synchronous generator has the following data:

$$x_d = 1pu, x_q = 0.4\,pu$$

If the generator is delivering rated kVA at rated voltage and at 0.8 pf leadisng, calculate the power angle and the excitation emf. Also draw the phasor diagram. Neglect the armature resistance.