Electrical Machines Practice Paper-I

(On Transformers – Basics, Ideal/Practical t/f, Eq. Ckt, O.C. & S.C. Tests)

① Estimate the active cross-sectional area of the core of a 20 turn, 1-phase, inductor for a terminal voltage of 100 V at 50 Hz. The flux density is about 1 wb/m². Give suitable dimensions for a square core. (Ans: 16 cm side)

② Calculate the core and window area required for a 1600 KVA, 6600/440 V, 50 Hz, Single-phase, core-type power transformer. Assume a maximum flux density of 1.2 wb/m² and a current density of 3 A/mm². Induced voltage per turn, 30 V; window space factor 0.32 (Ans: 1125 cm²; 1110 cm²)

③ Estimate the reduction in volume, expressed as a percentage of the original volume of (a) core iron (b) copper, in a transformer when ordinary steel plates worked at a flux density of 0.8 wb/m² are replaced by others of silicon steel worked at 1.2 wb/m² assuming the total flux to remain unchanged state any assumption made (Ans: (a) 33% (b) 18.4%)

④ Calculate the effective length and cross-sectional area of the airgap in an inductor with 300 turns required to have an induced emf of 100 V with a current of 10 A at 50 Hz. Assume maximum gap density of 1 wb/m² and that the iron requires 10% of the total ampere-turns. Ignore leakage and fringing

Ans: 4.8 mm; 15 cm²

⑤ The required no-load ratio in a 1-phase, 50 Hz core type transformer is 6000/250 V. Find the number of turns in each winding if the flux is to be about 0.06 wb (Ans: 450, 20)

(6) Estimate the active and reactive components of the no-load current of a 400V, 50Hz 1-phase transformer the particulars of which are as follows; core of transformer steel, length of mean magnetic path 200 cm; gross-cross-section 100 cm^2, Joints equivalent to 0.1 mm air gap; Max. flux density 0.7 wb/m^2; specific loss at 0.7 wb/m^2 and 50 Hz, 0.5 W per kg. Space factor 0.9. (Ans: 0.169A; 1.23A)

(7) The emf per turn for a single phase, 2310/220V, 50Hz transformer is approximately 13 volts. Calculate (a) the number of primary and secondary turns and (b) the net cross-sectional area of the core, for a maximum flux density of 1.4 wb/m^2. (Ans: (a) 189?, 18? (b) 393 cm^2)

(8) A 50 Hz single phase transformer, has one primary winding and two secondary windings. The primary is rated at 220 V and the secondaries are rated at 22 volts with a centre tapping and 600 V without any tapping. For a net core area of 75 cm^2, calculate the number of turns of the three windings. The maximum value of flux density is 1.2 wb/m^2 (Ans: 327, 120)

(9) A 33 KVA, 2200/220V, 50 Hz single phase transformer has the following parameters:

primary winding (h.v side) – resistance $r_1 = 2.4\Omega$; leakage reactance $x_1 = 6.0\Omega$

secondary winding (L.V side) – resistance $r_2 = 0.03\Omega$; leakage reactance $x_2 = 0.07\Omega$

(a) Find the primary resistance and leakage reactance reffered to secondary

(b) Find the secondary resistance and leakage reactance referred to primary

(c) Find the equivalent resistance and equivalent leakage reactance referred to (i) primary (ii) secondary

(d) Calculate the total ohmic loss at full load

(e) Calculate the voltage to be applied to the h.v side, in order to obtain a short circuit current of 160A in the l.v winding. Under these conditions, find the power input also

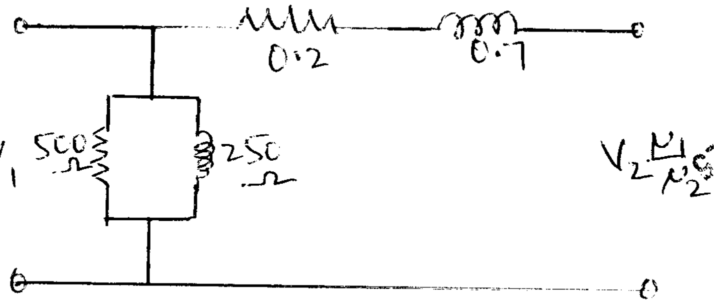
Ans: (a) 0.024Ω, 0.06Ω (b) 3.00Ω, 7.00Ω (c) 5.4Ω, 13Ω; 0.054Ω, 0.13Ω (d) 1216 watts (e) 16V, 1382 watts

(10) A 10KVA, 2500/250V, single phase transformer has resistances and leakage reactances as follows: $r_1 = 4.8\,\Omega$, $r_2 = 0.048\,\Omega$, $x_1 = 11.2\,\Omega$, $x_2 = 0.112\,\Omega$, subscripts 1 and 2 denote high voltage and low voltage windings respectively. With primary supply voltage held constant at 2500V, calculate secondary terminal voltage, when

(a) the L.V winding is connected to a load impedance of $5 + j3.5\,\Omega$

(b) The transformer delivers its rated current at 0.8 P.F lagging on the L.V side (Ans: (a) 242V (b) 241.55V)

(11) The equivalent circuit referred to the low-tension side of a 2500/250V single phase transformer is shown in figure.



The load impedance connected to the high-tension terminals is $380 + j230\,\Omega$. Compute (a) the secondary terminal voltage (b) primary current and power factor, and (c) power output and efficiency

Ans: (a) 2220 Volts (b) 5.1A, 0.794 lagg (c) 9500 watts, 93.83%.

(12) A 200 KVA, 11000/400V, delta-star distribution transformer gave the following test results:

open circuit test – 400 V, 9A, 1.50KW

short circuit test – 350 V, rated current, 2.1KW

Calculate the equivalent circuit parameters referred to the h.v side and its efficiency at half full load & unity power factor.

Ans: Efficiency at half full load = 98.02%.

(13) A 20-kVA, 50Hz, 2000/200 V distribution transformer has a leakage impedance of 0.42 + j0.52 Ω in the high-voltage (HV) winding and 0.004 + j0.05 Ω in the low-voltage (LV) winding. When seen from the LV side, the shunt branch admittance Y_0 is (0.002 − j0.015) ℧ (at rated voltage and frequency). Draw the equivalent circuit referred to (a) HV side and (b) LV side, indicating all impedances on the circuit.

Ans: (a) $\frac{1}{(10)^2}$ (0.002 − j0.015) (b) 0.0042 + j0.0052

(14) The following data were obtained on a 20-kVA, 50Hz, 2000/200V distribution transformer:

	Voltage (V)	Current (A)	Power (W)
OC test with HV open-circuited	200	4	120
SC test with LV short circuited	60	10	300

Draw the approximate equivalent circuit of the transformer referred to the HV and LV sides respectively.

(15) The magnetic circuit of figure has cast steel core with dimensions as shown: Mean length from A to B through either outer limb = 0.5m
Mean length from A to B through the central limb = 0.2 m.

In the magnetic circuit shown it is required to establish a flux of 0.75 mwb in the air-gap of the central limb. Determine the mmf of the exciting coil if for the core material (a) $\mu_r = \infty$ (b) $\mu_r = 5000$. Neglect fringing.