Cork Institute of Technology

Higher Certificate in Engineering in Electrical Engineering-Award

(NFQ Level 6)

Autumn 2006

Electrical Engineering

(Time: 3 Hours)

Attempt **Five** Questions

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1. (a) An impedance of (3-j4) Ω is connected in parallel with an impedance of (8+j6) Ω across a 20 V supply. Calculate the magnitude and power factor of the current taken from the supply. (8 marks)

   (b) A 230 V single phase supply has the following loads: (i) incandescent lamps taking a current of 8 A at a power factor of 1.0; (ii) fluorescent lamps taking a current of 12 A at a power factor of 0.6 lagging; (iii) a motor load of 8 A at a power factor of 0.8 lagging. Calculate the total supply current and the power factor. (8 marks)

   (c) What is the total power taken from the supply? (4 marks)

2. (a) State the numerical relationship between line and phase voltages and currents in a three-phase delta-connected load. (4 marks)

   (b) Three coils are connected in delta to a three-phase, three wire, 400-V, 50-Hz, supply and take a line current of 10A at 0.8 power factor leading. Calculate the resistance and inductance of each coil. (10marks)

   (c) If the coils are now connected in star across the same supply, calculate the line current and the power. (6 marks)

3. (a) Why is the three-phase four wire distribution normally used for A.C. distribution?(3 marks)

   (b) A three-phase 400 V system four-wire system has the following single-phase loads:

   Red phase 6 kW at 0.9 power-factor lagging,

   Yellow phase 3 kW at 0.7 power factor lagging,

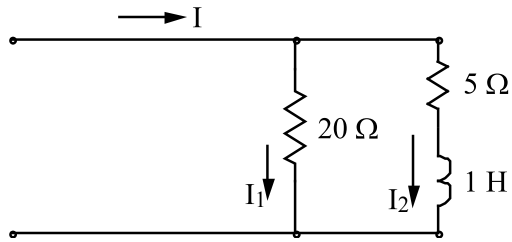
   Blue phase 9 kW at 0.8 power factor lagging.

   Calculate the current in each line and the neutral current.

   Assume the phase sequence to be R Y B (17 marks)

4. (a) Define the time-constant as applied to a circuit consisting of a resistance and an inductance connected in series. (3 marks)

   (b) In the circuit shown the supply is 5 V D.C. and is applied to the circuit at time t = 0. Find the values of the currents I, I_1 and I_2 under final steady state conditions. Find also the time constant of the inductive branch and the value of each current after 0.1 s. (17 marks)



5. (a) Explain with a circuit diagram how the open-circuit test is performed on a single phase transformer. What information can be got from the open-circuit test? (5 marks)

   (b) A single-phase transformer is rated at 1.8 kVA, 240 V/120 V. When the secondary terminals are open-circuited and the primary winding is supplied at normal voltage (240 V), the power taken is 20 W. When the secondary terminals are short-circuited, the power required to circulate full load current in the short-circuited secondary is 35 W. Calculate: (a) the efficiency of the transformer at full load, 0.8 power factor lagging; (b) the load at which maximum efficiency occurs. (15 marks)

6. (a) Explain how a rotating magnetic field is produced in a three-phase induction motor.

(5 marks)

   (b) The power input to a four-pole, three-phase, 50-Hz, induction motor is 64 kW; the speed is 1470 rev/min. The stator losses are 1.2 kW and the friction and windage losses are 2.0 kW. Find (i) the slip; (ii) the output power; (iii) the rotor copper loss: (iv) the efficiency.

(15 marks)

7. (a) Sketch the torque speed characteristic for a series type d.c. motor. What precautions should be taken when using this type of motor? (6 marks)

   (b) A series motor takes a current of 2 A from a 400 V d.c. supply and runs at 2,500 rev/min on light load. When the motor is loaded it takes 40 A from the same supply. Calculate the full load speed of the motor. The resistances of the armature and of the series field are 0.2 Ω and 0.1 Ω respectively. Assume that the flux is proportional to the field current and ignore the effects of armature reaction. (14 marks)

Useful Formulae

Capacitive Reactance $X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{-j}{\omega C} = \frac{1}{j\omega C}$ (Ω)

Inductive Reactance $X_L = \omega L = 2\pi f L = j\omega L$ (Ω)

Series Circuit

Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$ (Ω)

$$Cos\theta = \frac{R}{Z}$$

Parallel Circuit

Two Impedances in Parallel $Z_T = \frac{Z_1 Z_2}{Z_1 + Z_2}$

Only when Z_1 and Z_2 are expressed in complex form.

Time Constant $T = \frac{L}{R}$ (s)

Growth of Current in a RL circuit

$$i = \frac{V}{R}\left\{1 - e^{\frac{-Rt}{L}}\right\} \quad \text{(A)}$$

Voltage across inductance $v_L = V\left\{e^{\frac{-Rt}{L}}\right\}$ (V)

Three-Phase Star Connection

$$V_{Line} = \sqrt{3}V_{Phase}$$

$$I_{Line} = I_{Phase}$$

Power in Balanced Load $P = \sqrt{3}V_L I_L Cos\theta$ (W)

Three-Phase Delta Connection

$$V_{Line} = V_{Phase}$$

$$I_{Line} = \sqrt{3}I_{Phase}$$

Power in Balanced Load $P = \sqrt{3}V_L I_L Cos\theta$ (W)

Unbalanced Load $P_T = P_1 + P_2 + P_3$ (W)

Power Factor Correction $Cap.kVAr = kW(Tan\theta_2 - Tan\theta_1)$

Power Factor $= \frac{TruePower}{ApparentPower}$

Reactive Power $= VISin\theta$ (VArs)

True Power $= VICos\theta$ (W)

Apparent Power $= VI$ (VA)

Ideal Transformer $\frac{V_P}{V_S} = \frac{N_P}{N_S} = \frac{I_S}{I_P}$

Approximate Volt Drop $I_P \overline{R}_P Cos\theta \pm I_P \overline{X}_P Sin\theta$ (V)

Per Unit Regulation $\frac{V_{NL} - V_{FL}}{V_{NL}}$

$$\frac{ApproximateVoltDrop}{V_P} x100\%$$ (%)

Synchronous speed N_s = 60f/p (r/min)

f = frequency

p = pairs of poles

Per Unit Slip $s = \frac{N_s - N_r}{N_s}$

Rotor Speed $N_r = N_s(1-s)$ (r/min)

Rotor Frequency $f_r = sf$

DC Machines

D.C. Motor

$E_b = V - I_a R$ (V)

$N = K\frac{V - I_a R}{\phi}$ (r/min)

$E_b = KN\phi$