GR 332

Jm0009

OLLSCOIL NA hÉIREANN, GAILLIMH
THE NATIONAL UNIVERSITY OF IRELAND, GALWAY

SPRING EXAMINATIONS, 1998

THIRD YEAR ELECTRONIC ENGINEERING
THIRD YEAR MECHANICAL ENGINEERING

ELECTRICAL POWER AND MACHINES

Professor F. Eastham
Professor D.J. Wilcox
Dr. W.G. Hurley

Duration of examination: *Three* Hours

Instructions : Answer *five* questions.
$\mu_o = 4\pi \times 10^{-7}$ H/m
1 h.p.=746 W

Q.1 Explain why an airgap is normally used in the construction of an inductor.

A magnetic circuit is arranged as shown in Figure 1. The centre limb is wound with 500 turns and has a cross-sectional area of 800 mm^2. Each of the outer limbs has a cross-sectional area of 500 mm^2. The airgap has a length of 1 mm. The mean lengths of the various magnetic paths are shown in the diagram. The relative permeability of the magnetic material is 1200. Calculate:

(a) the reluctances of the centre limb, the airgap and the two outer limbs.
(b) the current required to set up a flux of 1.3 mWb in the centre limb, assume there is no magnetic leakage or fringing.
(c) the energy stored in the airgap in (b).

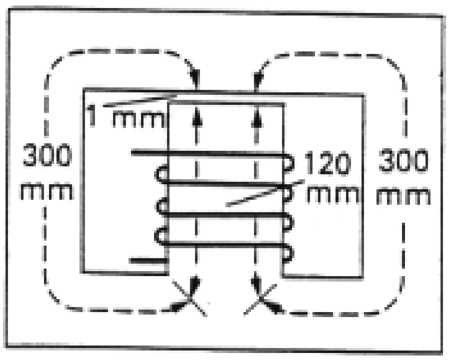

Figure 1

contd./

Q.2 List three functions which a transformer may perform in an electrical circuit.

In a 40 kVA 2000/250V single phase transformer, $R_1 = 1.15\ \Omega$, $X_{e1} = 3.5\ \Omega$, $R_2 = 0.0155\ \Omega$ and $X_{e2} = 0.5\ \Omega$, calculate:

(a) the total resistance and reactance referred to the primary (2000 V) winding
(b) the secondary voltage when carrying full-load current at 0.8 power factor lagging.
(c) the regulation in (b).

Q.3 Explain why the rms value of the primary current in a transformer connected to the a.c. supply is not zero when the secondary current is zero.

A single phase transformer has 480 turns on the primary and 90 turns on the secondary. The mean length of the flux path in the core is 1.8 m. The maximum flux density is limited to 1.1 T when a potential difference of 2200 V at 50 Hz is applied to the primary. Calculate:

(a) the cross-sectional area of the core
(b) the secondary voltage on no-load
(c) the primary current and power factor when the core loss is 1.7 W/kg and the density of the core material is 7800 kg/m^3.

The relative permeability of laminated steel is 2000.

Q.4 Describe three methods by which the speed of a d.c. motor may be controlled.

Two adjustable speed d.c. shunt motors have speed ranges 500 r.p.m. to 1850 r.p.m. Motor A has a constant power load and motor B has a constant torque load. Speed adjustment is by field rheostat.

(a) If the power outputs are equal at 1850 r.p.m. and the armature currents are each 100A, calculate the armature currents at 550 r.p.m.
(b) If the power outputs are equal at 550 r.p.m. and the armature currents are each 100A, calculate the armature currents at 1850 r.p.m.

Neglect all losses.

Q.5 Establish the equivalence between star and delta connections in a three-phase system.

A star-connected alternator, in which the e.m.f. generated in each phase is 1905 V, supplies a delta connected 200 hp induction motor which has a full load efficiency of 92% and a power factor of 0.9 lagging. Calculate the line current and phase current for both motor and alternator. Neglect losses in the connecting cable.

contd./

Q.6 Draw the equivalent circuit of an induction motor and explain each element in it.

A 4-pole 3-phase 50 Hz induction motor with a star-connected rotor has resistance per phase of 0.2 Ω and at standstill the reactance per phase is 1.0 Ω. The e.m.f. between the slip rings at standstill is 120 V. If the full-load speed is 1440 r.p.m., calculate:

(a) the slip
(b) the e.m.f. induced in each phase of the rotor
(c) the rotor reactance per phase
(d) the rotor current and power factor, assume the rings are short-circuited.

Q.7 Define the following terms: displacement factor, distortion factor and power factor.

The distorted source e.m.f. in a series R-L circuit may be represented as

$$e(t) = 100 \text{ Sin } \omega t + 30 \text{ Sin } (3\omega t + 20^\circ) + 10 \text{ Sin } (5\omega t + 10^\circ)$$

the fundamental frequency being 50 Hz.

For a circuit in which R = 5 Ω and L = 20 mH, calculate:

(a) the amplitudes of the fundamental, 3rd and 5th harmonics of current
(b) r.m.s. value of the source current
(c) the power factor of the source.