University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SPRING TRIMESTER EXAMINATIONS

ACADEMIC YEAR 2019/2020

EEEN20090 – Electrical Energy Systems

External Examiner: Prof. Vincent Fusco

Head of School: Prof. Peter Kennedy

Head of Subject: Prof. Federico Milano

Module Coordinator: Prof. Federico Milano *

Time Allowed: 2 hours

Student Number

Seat Number

Instructions for Candidates

Answer all questions from any three of the five sections. All question papers **must** be handed up with the answer booklets at the end of the exam. The distribution of marks in the right margin gives an approximate indication of the relative importance of each part of the question.

Instructions for Invigilators

Non-programmable calculators are permitted.

Section A

A 120 V per phase, three-phase, Y-connected source delivers power to the following Δ-connected load (see Figure 1):

- Phase 1: $40\angle 0\ \Omega$;
- Phase 2: $20\angle -60^\circ\ \Omega$;
- Phase 3: $15\angle 45^\circ\ \Omega$.

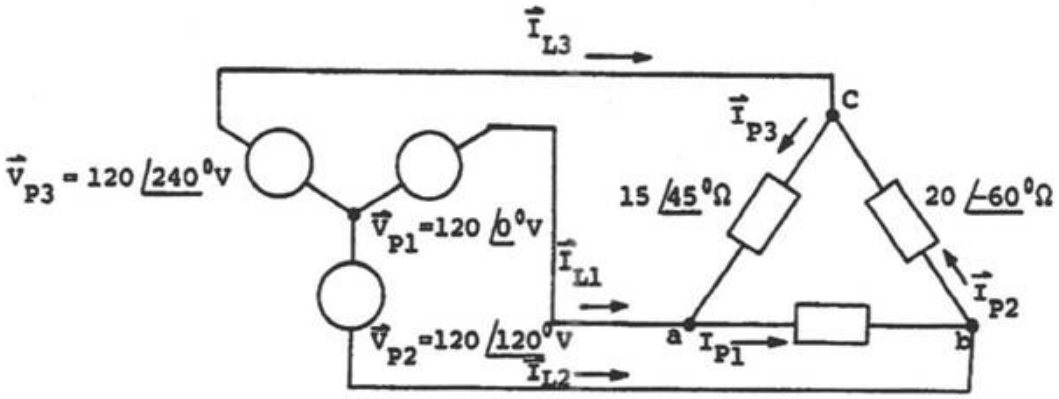

Figure 1

Determine:

1. Line voltages ($\bar{V}_{L1} = \bar{V}_{ab}$, $\bar{V}_{L2} = \bar{V}_{bc}$, $\bar{V}_{L3} = \bar{V}_{ca}$). 40%
2. Phase currents ($\bar{I}_{P1}$, $\bar{I}_{P2}$, $\bar{I}_{P3}$). 30%
3. Line currents ($\bar{I}_{L1}$, $\bar{I}_{L2}$, $\bar{I}_{L3}$). Show that the line currents add up to zero. 30%

Section B

Figure 2 shows the scheme of an electromagnetic relay. The current circulating in the winding is 30 mA. The iron core is circular and its radius is 15 mm. The reluctance of the iron core and flux fringing are negligible.

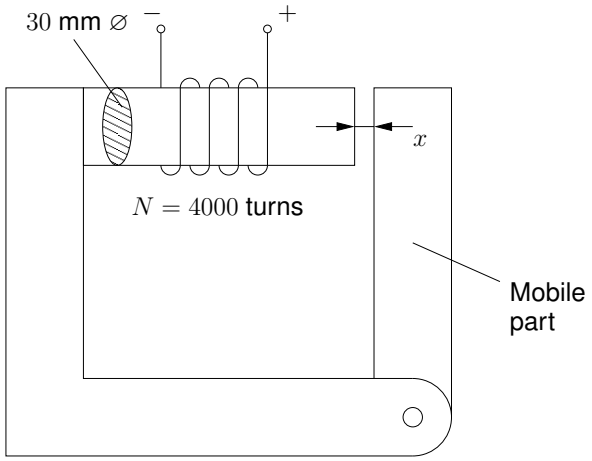

Figure 2

Determine:

4. The force (f) acting on the mobile part of the magnetic circuit and the self-induction coefficient (L) of the winding for $x = 3.5$ mm. 50%
5. The variation of stored magnetic energy (ΔW_f) if the mobile part moves *slowly* from $x_1 = 3.5$ mm to $x_2 = 5$ mm. 50%

Section C

A 60-Hz, four-pole, Y-connected induction motor is rated 3.7 kW, 220 V (line to line). The equivalent circuit parameters are:

$$R_1 = 0.48\ \Omega \qquad R_2' = 0.42\ \Omega$$
$$X_1 = 0.80\ \Omega \qquad X_2' = 0.80\ \Omega \qquad B_\mu = 1/30\ \Omega^{-1}$$

The motor is operating with slip of 0.04. Determine:

6. Stator current (I_1) and the motor power factor ($\cos\phi_1$). 50%
7. The mechanical power (P_m) and the mechanical torque (T_m). 50%

Section D

A 1000 kVA, 4600 V, three-phase, Y-connected alternator has an armature resistance R_a of $2\ \Omega$ per phase and a synchronous armature reactance, X_s, of $20\ \Omega$ per phase.

Find the full-load generated voltage ($\bar{E}_g$) per phase at:

8. Unity power factor. 50%

9. A power factor of 0.75 lagging. 50%

Section E

A 440-V rms (line voltage) symmetrical three-phase system feeds two balanced Y-connected loads. One load is an induction motor which may be represented by an impedance of $10 + j5\ \Omega$ per phase. The other is a lighting load equivalent to $15\ \Omega$ per phase.

Find the average active power:

10. Delivered to the lighting load (P_L);. 30%

11. Delivered to the induction motor (P_M). 30%

12. Provided by one phase of the source (P_S). 40%

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