University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER II EXAMINATIONS - 2017/2018

School of Electrical and Electronic Engineering

EEEN20090 – Electrical Energy Systems

External Examiner: Prof. Andrew Gibson

Head of School: Prof. Andrew Keane

Module Coordinator: Prof. Federico Milano *

Time Allowed: 2 hours

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.
No rough-work paper is to be provided for candidates.

Student No: _____ **Seat No:** _____

Section A

A symmetrical three-phase source serves three loads, as follows:

- $\bar{Z}_A = 50 + j80\ \Omega$
- $\bar{Z}_B = j50\ \Omega$
- $\bar{Z}_C = 100 + j25\ \Omega$

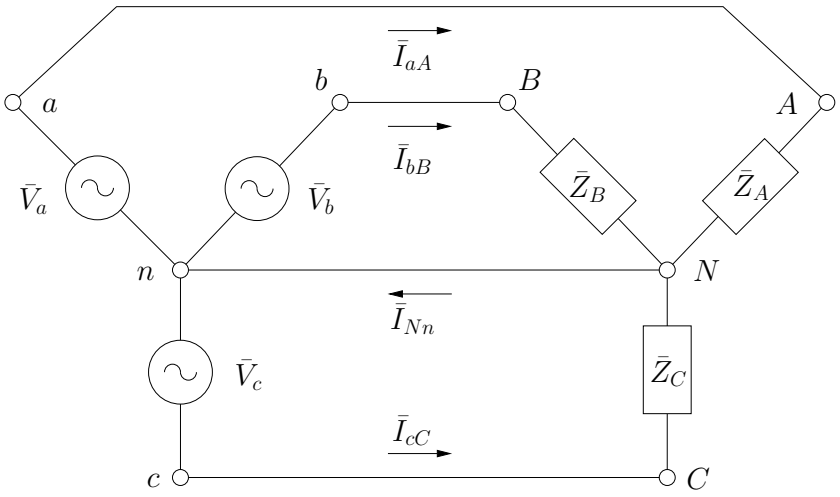

Figure 1

If the line voltage at the loads is 110 V rms at 60 Hz, determine:

1. The line currents, $\bar{I}_{aA}$, $\bar{I}_{bB}$, $\bar{I}_{cC}$. 40%
2. The current in the neutral connection, $\bar{I}_{Nn}$. 20%
3. The complex power delivered to the 3-phase load, $\bar{S}$. 40%

Note: assume that $\bar{V}_a$ is the phase reference.

Section B

For the doubly excited system in Figure 2, the inductances, expressed in Henrys, are approximated as follows:

$$L_1 = 11 + 3\cos 2\theta; \quad L_2 = 7 + 2\cos 2\theta; \quad M = 11\cos\theta$$

The coils are energized with direct currents: $i_1 = 0.7$ A; $i_2 = 0.8$ A.

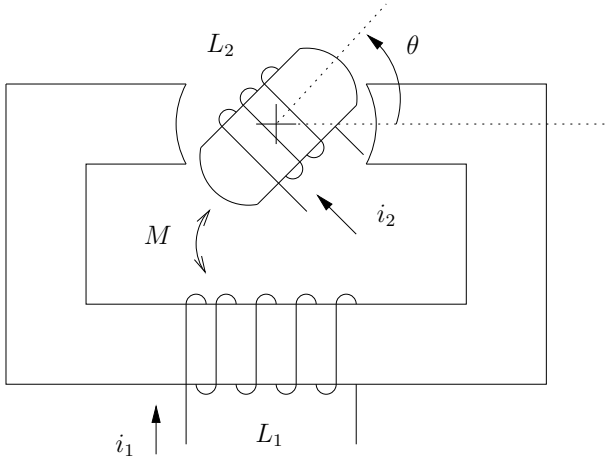

Figure 2

Determine:

4. The torque T as a function of θ. 50%

5. The energy stored W in the system as a function of θ. 50%

Section C

The power absorbed by a three-phase, 4 pole, 50 Hz induction motor rotating at 1435 rpm is 4.76 kW. The total stator losses of the motor are 265 W and the mechanical losses are 300 W.
Determine:

6. The slip factor σ. 25%

7. The losses in the rotor winding, P_{j2}. 25%

8. The net mechanical power available at the motor shaft, P_m. 25%

9. The efficiency η of the motor. 25%

Section D

The synchronous impedance of a three-phase star-connected $6,660$ V synchronous generator is $0.4 + j6\ \Omega$.
Determine the voltage regulation $\Delta V_{\%}$ of the machine when the machine generates 1000 kW at the rated voltage with the following power factors:

10. Unity. 40%

11. 0.866 lagging. 40%

12. 0.866 leading. 20%

Section E

A 480 V rms line feeds two three-phase loads. The two loads are rated as follows,

- Load 1: 40 kW at 0.8 pf lagging
- Load 2: 30 kVA at 0.9 pf leading

The two loads are connected in parallel and are fed through a transmission line with impedance $0.1 + j0.2\ \Omega$ per phase.
Assuming that the voltage at the load is 480 V rms, determine:

13. The line current magnitude, I_s, from the 480 V rms source. 25%

14. The combined power factor, $\cos\phi_L$, of the load. 25%

15. The voltage magnitude at the source, V_s. 25%

16. The power factor at the source, $\cos\phi_s$. 25%

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