University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS - 2018/2019

School of Electrical and Electronic Engineering

EEEN20090 – Electrical Energy Systems

External Examiner: Prof. Andrew Gibson

Head of School: Prof. Peter Kennedy

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 section.

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 set of three-phase voltages is connected to an unbalanced set of Y-connected impedances as shown in Figure 1. The following values are known:

$$\bar{V}_{ab} = 212\angle 90^\circ \text{ V}, \qquad \bar{Z}_{an} = 10 + j0\ \Omega$$
$$\bar{V}_{bc} = 212\angle 150^\circ \text{ V}, \qquad \bar{Z}_{bn} = 10 + j10\ \Omega$$
$$\bar{V}_{ca} = 212\angle -30^\circ \text{ V}, \qquad \bar{Z}_{cn} = 0 - j20\ \Omega$$

Find the line currents $\bar{I}_{a'a}$, $\bar{I}_{b'b}$, and $\bar{I}_{c'c}$.

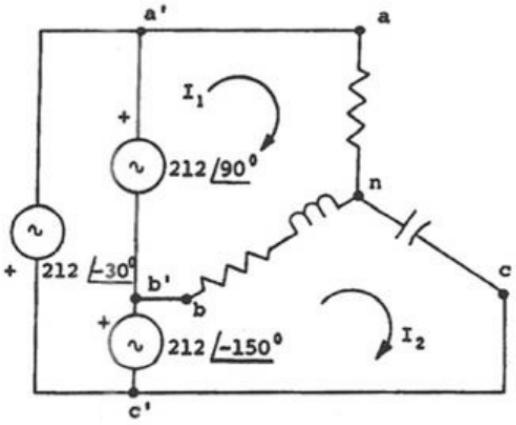

Figure 1

Section B

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

$$L_1 = 5 + 2\cos 2\theta; \quad L_2 = 3 + \cos 2\theta; \quad M = 10\cos\theta$$

The coils are energized with direct currents: $i_1 = 1$ A; $i_2 = 0.5$ A.
Determine:

1. The energy stored W in the system as a function of θ. 50%
2. The torque T as a function of θ. 50%

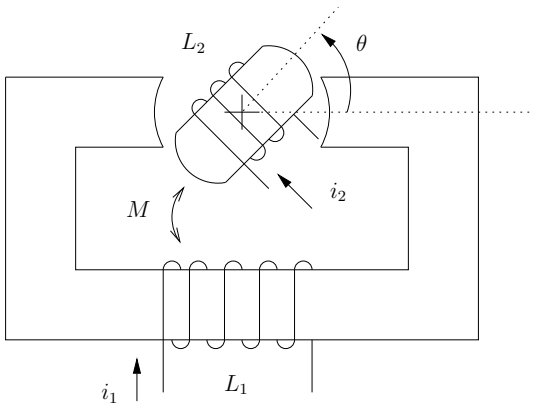

Figure 2

Section C

The stator and rotor impedances of a three-phase, 4 pole, 50 Hz, 380 V induction motor are $R_1 + jX_1 = 0.1 + j0.4\ \Omega$ and $R_2' + jX_2' = 0.1 + j0.3\ Omega$. The nominal slip is 4%.
Determine:

3. Synchronous speed and nominal speed. 25%

4. Nominal current and start-up current. 25%

5. Nominal power and nominal torque. 25%

6. The efficiency, assuming that iron losses are 1200 W. 25%

Section D

The synchronous impedance of a three-phase star-connected 15 kV synchronous generator is $0.5 + j10\ \Omega$.
Determine the voltage regulation $\Delta V_{\%}$ of the machine when the machine generates 2000 kW at the rated voltage with the following power factors:

7. Unity. 40%

8. 0.9 lagging. 40%

9. 0.9 leading. 20%

Section E

A 13.8 kV feeder supplies three loads:

- Load 1: 700 kVA, 0.8 lagging
- Load 2: 1000 kVA, 0.5 lagging
- Load 3: 800 kVA, 0.9 lagging

Determine:

10. Current of the feeder required to feed the three loads. 40%

11. The combined power factor of the three loads. 30%

12. The value of the capacitor to add in parallel with the three loads to change the overall power factor to 0.92 lagging. 30%

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