University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SPRING TRIMESTER EXAMINATIONS

ACADEMIC YEAR 2020/2021

EEEN20090 – Electrical Energy Systems

External Examiner: Prof. Vincent Fusco

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 question.

Instructions for Invigilators

Non-programmable calculators are permitted.

Section A

A Y-connected three-phase source serves a Y-connected three-phase load. The load is balanced and has an impedance $\bar{Z} = 20 + j10\ \Omega$ per phase, whereas the phase-to-neutral voltages of the source are as follows:

- $\bar{V}_A = 110\angle 0$ V
- $\bar{V}_B = 90\angle -120°$ V
- $\bar{V}_C = 130\angle 120°$ V

Calculate the line currents ($\bar{I}_A$, $\bar{I}_B$, $\bar{I}_C$) in the following conditions:

1. With a neutral conductor with impedance $\bar{Z}_N = j5\ \Omega$ that connects the star points of the source and the load. 50%

2. Without any neutral conductor. 50%

Section B

The relationship between the current i and the total magnetic flux λ in a nonlinear magnetic circuit with a mobile part is given by:

$$i = kx^3\lambda^2$$

where k is a positive coefficient and x is the position of the mobile part. Determine:

3. The magnetic energy (W) stored in the magnetic circuit as a function of x and λ. 35%

4. The coenergy (W') of the circuit as a function of x and i. 35%

5. The force (f) generated by the magnetic circuit. 30%

Section C

The rotor speed of a three-phase Y-connected induction motor is 850 rpm at full load. The nominal frequency of the motor is 60 Hz. The net mechanical power, efficiency and the power factor of the motor at full load are 5230 W, 86% and 0.7, respectively. The motor has 4 pairs of poles and its nominal phase-to-neutral voltage is 380 V. Determine:

6. The synchronous speed of the motor (ω_{s1}). 30%

7. The slip factor (σ_N) and the line current magnitude (I_L) at full load. 40%

8. Rotor Ohmic losses (P_{j2}) and mechanical losses (P_{ml}) at full load if the combined losses in the stator and in the iron core are 410 W. 30%

Section D

A 2 MVA, 22 kV, three-phase, Y-connected alternator has an armature resistance R_a of $10\ \Omega$ per phase and a synchronous armature reactance X_s of $50\ \Omega$ per phase.

Find the voltage regulation ($\epsilon_v = (E - V)/V$, where E is the internal emf and V the stator terminal bus voltage of the machine) for the following operating conditions:

9. Open circuit. 20%

10. 75% of the full-load and unity power factor. 40%

11. Full-load and a power factor of 0.75 leading. 40%

Section E

A balanced three-phase source supplies power to four loads connected in parallel through a line with impedance $0.02 + j0.2\ \Omega$ per phase. The four loads are:

- Load 1: 20 kVA at 0.8 pf lagging
- Load 2: 10 kW at 0.7 pf leading
- Load 3: 10 kW at unity pf
- Load 4: 8 kVAr at 0.6 pf lagging

If the line voltage at the point of connection of the loads is 380 V, determine:

12. The power factor ($\cos\phi_L$) at the point of connection of the loads. 50%

13. The voltage magnitude (V_S) and the power factor ($\cos\phi_S$) at the source. 50%

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