UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE *ENGINEERING: ELECTRICAL*
SUBJECT	:	**ELECTRICAL MACHINES IV**
CODE	:	**TEF 441**
DATE	:	MAIN EXAMINATION / NOVEMBER 2014 12/NOV/2014 ; 08 :30
DURATION	:	3 HOURS
WEIGHT	:	40: 60
TOTAL MARKS	:	**100**
FULL MARKS	:	**100**

ASSESSOR	:	MR. M.C MUTEBA
MODERATOR	:	Dr. C. RICHARDS
NUMBER OF PAGES	:	5 PAGES

REQUIREMENTS

- STANDARD STATIONARY.
- NO-PROGRAMMABLE CALCULATOR MAY BE USED

INSTRUCTIONS

- READ INSTRUCTIONS CAREFULLY.
- ALL CALCULATIONS AND ANSWERS MUST BE DONE WITH A MINIMUM OF 3 DECIMALS.
- WRITING MUST BE IN BLUE OR BLACK INK PEN ONLY- NO PENCIL WRITING WILL BE MARKED
- WORK NEATLY, UNTIDY WORK MAY BE PENALIZED.
- ALL UNITS MUST BE SHOWN-MARKS WILL BE DEDUCTED FOR NO OR WRONG UNITS
- ALL CALCULATIONS MUST BE DONE IN COMPLEX NOTATION AND ANSWERS MUST BE WRITTEN IN POLAR FORM, WHERE APPLICABLE.

SECTION A:

GENERAL INTRODUCTION AND OPERATION OF SYNCHRONOUS MACHINES

QUESTION 1 **[25 Marks]**

1.1 An 8-pole, 72 stator-slots, three-phase, star-connected, 50 Hz, synchronous generator has 10 conductors per slot in two layers. The flux per pole has a fundamental component of 0.1 Webber and 20 % third component. The coils are chorded by 1 slot. Compute the RMS of the induced (line) e.m.f. **(12)**

1.2 Illustrate with a drawing the brushless method of excitation of synchronous machines **(5)**

1.3 The measured resistance between the stator terminals of a 1-MVA, star-connected, 3.3 kV, cylindrical rotor, synchronous generator is 1.2 Ω. An exciting current of 2.5 A gives a no-load line voltage of 3031 V and full-load short-circuit current. By means of the impedance method, calculate the % full-load voltage regulation at 0.8 power factor lagging. **(8)**

QUESTION 2 **[14 Marks]**

2.1 The synchronous reactance of a salient-pole synchronous generator has a direct-and quadrature-axis of 0.9 p.u and 0.6 p.u respectively. Determine the load angle, the p.u induced e.m.f and the full-load voltage regulation for a power factor of 0.8 lagging. Neglect the armature resistance. **(4)**

2.2 A 1-MVA, three-phase alternator has a synchronous impedance of (0.104 +j0.59) p.u. Calculate at full-load and power factor of 0.8 lagging the p.u electromagnetic power. **(4)**

2.3 A 6-pole, 150 kW, 50 -Hz, 460 V, and 3-phase cylindrical rotor synchronous motor has a synchronous reactance of 0.8 Ω, per phase and efficiency of 96 %. The machine operate at rated condition with 0.8 power factor leading. Compute the power developed. **(6)**

[39 Marks]

SECTION B

APPLICATION AND STABILITY OF SYNCHRONOUS MACHINES

QUESTION 1 **[23 Marks]**

1.1 Discuss hunting under the headings:

1.1.1 Disadvantages. **(3)**

1.1.2 Causes **(3)**

1.1.3 Method of minimizing. **(3)**

1.2 One of the techniques to determine whether the synchronous generator connected to infinite busbar will attain its steady equilibrium position after oscillation is by means of the Swing Equation *Equal-Area Criterion.* Discuss the technique; neglect the damping torque. **(8)**

1.3 Draw a typical synchronous machine capability curve and clearly indicate the thermal limits for field and armature currents. Also indicate the stability limit, the MVA and power factor Ratings. **(6)**

QUESTION 2 **[6 Marks]**

Two 10 MVA synchronous generators are connected to 50 Hz to 50 Hz busbars having a constant voltage of $1\angle 0^{o}$ p.u. Generator A has an induced e.m.f of $1.3\angle 22^{o}$ p.u. and a reactance of 0.5 p.u, generator B an e.m.f of $1.25\angle 36^{o}$ p.u. and a reactance of 0.75 p.u. Find the current, kW and kVAR supplied by each generator.

[29 Marks]

SECTION C:

BASICS OF ELECTRICAL MACHINE DRIVES AND CONTROL

QUESTION 1 [8 Marks]

1.2 A trolley-bus is driven by a 150 hp, 1500 RPM, 600 series dc motor as in figure 1. The nominal full-load current is 200 A and the total resistance of the armature and field is 0.1 Ω. The bus is fed from a 700 V dc catenary line. A chopper controls the torque and the speed. The chopper frequency varies from 50 Hz to 1600 Hz, but "ON" time T_a is fixed at 600 x 10^{-6} seconds.

1.2.1 Calculate the chopper frequency and the current drawn from the catenary line when the motor is at standstill and drawing a current of 240 A. **(4)**

1.2.2 Calculate the chopper frequency when the motor delivers its rated output. **(4)**

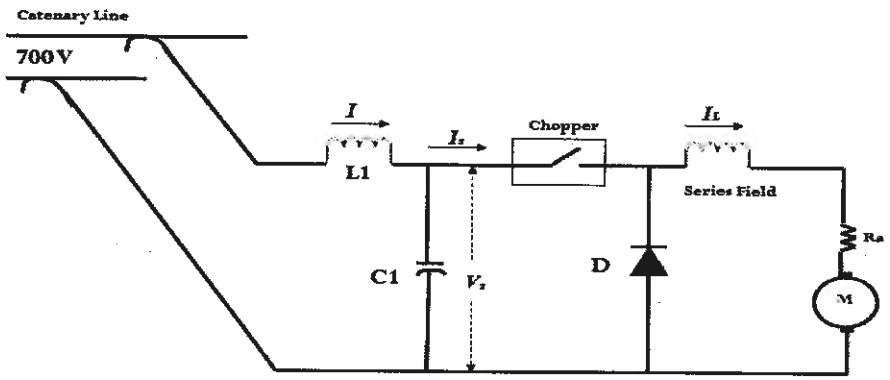

Figure 1: Direct Current motor driven by a chopper

QUESTION 2 [8 Marks]

A 40 hp, 1165 RPM, 460 V, 52 A, 50 Hz, 3-phase squirrel cage induction motor is driven by a current-source frequency converter. The efficiency of motor is 88 % and that of the inverter is 99.4 %. Referring to figure 2, calculate the approximate value of the following:

2.1 The dc power input to converter 2 **(3)**

2.2 The current in the dc link **(2)**

2.3 The dc voltage V_{dc} produced by converter 1 **(3)**

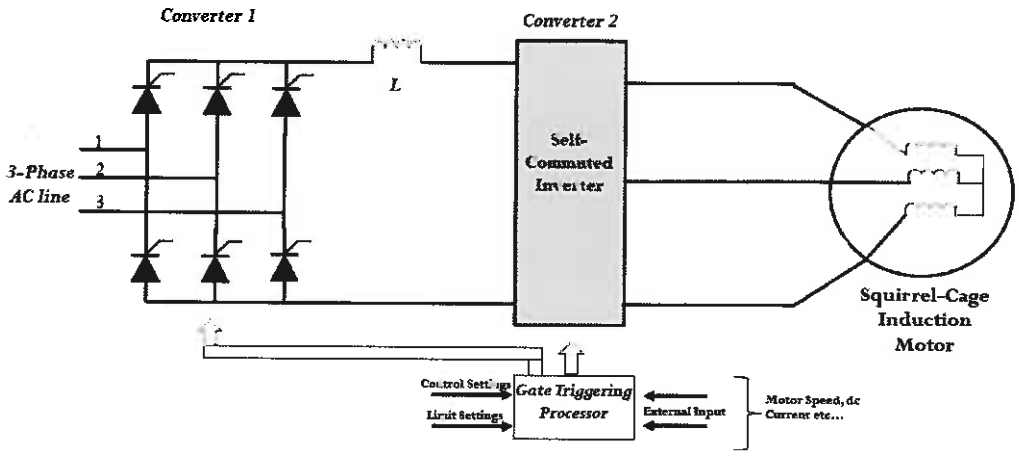

Figure 2: Three-Phase Squirrel Cage Induction Motor Driven by a Current-Fed Frequency Converter

[16 Marks]

SECTION D

INTRODUCTION TO GENERALIZED MACHINE AND REFERENCE FRAME THEORIES

QUESTION 1

[8 Marks]

Write the voltage equations of stator and rotor coils of the primitive machine and combine these two equations into a single matrix equation.

QUESTION 2

[8 Marks]

A change of variables that formulates a transformation of 3-phase variables of stationary circuit elements to the arbitrary reference frame can be expressed as follows:

$$f_{qd\,0s} = K_S\, f_{abc}$$

Express K_S *and* $(K_S)^{-1}$ in simple matrix equations

[16]

END

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