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TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering

Department of Electrical and Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Technology in Electrical Engineering

TEE 4315: ELECTRICAL MACHINES III

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: April 2025

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.

Do not write on the question paper.

Question ONE (Compulsory 20 marks)

(a)(i) Explain why non- salient rotors are preferred to salient ones in alternator operation **(2mks)**

(ii) With aid of a sketch describe the operation of an alternator **(4mks)**

(iii) A 2500kVA, 4kV, 3Phase star connected alternator has effective armature resistance of 0.2Ω per phase and a synchronous reactance of 0.5Ω/phase. Find the percentage change in terminal voltage when the rated output of 2500kVA at (i) Unity p.f (ii) 0.8p.f leading **(4mks)**

(b) (i) Describe THREE factors which result to drop in the terminal voltage of an alternator when the load is increased keeping field excitation and speed constant**(3mks)**

(ii) With aid of sketch derive equations for E_0, E and V **(3mks)**

(iii) A 1200kVA, 3300V, 50Hz three phase star connected alternator has an armature resistance of 0.25Ω per phase. A field current of 40A produces a short circuit current of 200A and an open ciruit

emf of 1100V line to line. Find voltage regulation on full load at 0.8 power factor lagging factor lagging. **(4mks)**

Question TWO

(a)(i) With aid of a sketch illustrate the infinite busbar (**3mks)**

(ii) Explain how infinite busbar voltage and frequency can be lowered or increased **(2mks)**

(iii) Two 70MVA, 3phase, alternators operate in parallel. The setting of the governors are such that rise in speed from full load to no load is 2% in one machine and 3% in the other machine, the characteristics being a straight line in both cases. If each machine is fully loaded, when the total load is100MW, what would be the load on each machine when the total load is 60MW? **(5mks)**

(b)(i)Describe the effect of increase in power input to the prime mover of an alternator, keeping excitation constant with aid of an equivalent phasor diagram **(3mks)**

(ii) State FOUR conditions which must be met for an alternator to be connected to infinite bus bar **(3mks)**

(iii) Two alternators A and B operate in parallel and supply a load of 8000kW at 0.8pf lagging. The power output of A is adjusted to 5000kW by changing its steam supply and its power factor to 0.9pf lagging by changing its excitation. Find the power factor of alternator B **(4mks)**

Question THREE

(a)(i) State TWO advantages of operating alternators in parallel **(2mks)**

(ii) Describe synchronizing power with aid of a sketch and show that for an alternator not connected to the load it can be given by $3Psy = \frac{3\alpha E^2}{2XS}$ **(4mks)**

(iii) A 3000kVA, 6pole alternator runs at 1000rpm in parallel with other machines on 3300V bus bars. The synchronous reactance is 25% of voltage E. Calculate the synchronizing power for one mechanical degree of displacement and the corresponding synchronizing torque **(4mks)**.

(b) (i) Define synchronous torque and derive its expression **(2mks)**

(ii) With aid of sketch describe three lamps method of synchronization **(4mks)**

(iii) A lighting load of 3000KW and a motor load of 5000kW at 0.65pf lagging is supplied by two alternators running in parallel. One machine is loaded to 3600KW at 0.85pf lagging. What is the kW output and power factor of the second machine **(4mks)**

Question FOUR

(a)(i)Define the following as used in alternator winding (i) Distribution factor (ii) Expression factor **(2mks)**

(ii) With aid of a sketch the synchronous impedance method of measurement of voltage regulation of an alternator **(4mks)**

(iii) Calculate the distribution factor for a single phase alternator having 6slots/pole (i) When all slots are wound (ii) When only four adjacent slots per pole are wound the remaining slots being unwound **(4mks)**

(b)(i)Describe how to determine the following parameters an alternator; (i) Open circuit characteristics (ii) Short circuit characteristic **(3mks)**

(ii) Explain how infinite busbar voltage can be lowered or increased **(3mks)**

(iii) A 12pole, 3phase alternator has 72slots.The flux per pole is 0.0988wb. Calculate (i) The speed of rotation if frequency of the generated e.m.f is 50Hz (ii) The terminal e.m.f for full pitch coils and 8 conductors per slot (iii) The terminal e.m.f if the coil span is reduced to 2/3 of the pitch **(4mks)**

Question FIVE

(a)(i) With aid of sketch describe the construction of a synchronous motor **(4mks)**

(ii) Explain why a synchronous motor is not self-starting**(2mks)**

(iii) A 2000V, 3phase, star connected motor has resistance and synchronous reactance per phase of 0.2Ω and 9Ω respectively. Calculate the generated back emf per phase with an input of 800KW at 0.8 pf lagging.**(4mks)**

(b) (i) Describe the V curves of a synchronous motor **(3mks)**

(ii) Describe the pull out torque of a synchronous motor **(3mks)**

(iii) A 3980V, 50Hz, 4pole star connected synchronous motor generates back emf of 1790V per phase. The resistance and synchronous reactance per phase are 2.2Ω and 22Ω respectively. The torque angle is 30electrical degrees. Calculate (i) Resultant armature voltage/phase (ii) armature current per phase (iii) power factor of the motor (iii) Gross torque developed by the motor**. (4mks)**