UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

Department of Electrical and Electronic Engineering

July 2016
SUPPLEMENTARY EXAMINATION

Title of the Paper:

Electrical Machines

Course Number: EE451
Time Allowed: Three Hours.

Instructions:

1. Answer all questions, no choice.
2. The answer must be written in the space provided in the question book. Use the answer book as a scratch pad. Both the question and answer book must be marked with ID and name and handed in as well.
3. This paper has 6 pages, including this page.

DO NOT OPEN THE PAPER UNTIL
PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

Q1, (20pts): A 75-KVA 24000:400-V 3-φ transformer, Δ-Y connected is under a performance test. A short-circuit test gives the instrument readings: 480V, 1.804A, and 620W. An open-circuit test gives instrument readings: 400V, 5.4A, and 580W. Find:

(i). the copper loss and the iron loss.

(ii). the series parameters of the transformer

(iii). the parallel parameters of the transformer

(iv). draw the equivalent circuit in pu of this transformer.

Q2, (20 pts): Given a 3-φ, Y connected induction motor is rated at 380 V, 15 KW, 50Hz, and 4-pole. The friction windage and core loss is assumed to be a constant independent of load at 400 W. The motor is operated under rated terminal voltage and frequency. The motor constants are:

R_1=0.6, R_2=0.3, X_1=2.7, X_2=0.5, and X_M=27 Ω

Evaluate the performance at a rated slip of 5%:

(i). motor speed,

(ii). stator current,

(iii). out put shaft torque and power,

(iv). motor power factor and efficiency.

Q3, (20 pts): A synchronous generator is rated: 100 MVA, 11.5 KV. 50 Hz, 2-pole, and Y connected. It has a synchronous reactance of 0.8 pu and armature resistance of 0.01.

(i). When field over-excited, operating at a leading power factor, sketch the phasor diagram, relating V_a, I_a and E_a. Mark explicitly the angle φ and δ.

(ii). When feed to a load at rated conditions and a power factor 0.8 lagging, find the generated internal voltage E_a,

(iii). torque angle δ, and

(iv). prime mover torque required.

Q4, (20 pts): A 220 V shunt DC motor runs on no-load at 1600 rpm. The no-load current is 8 A. The armature circuit resistance is 0.25Ω and shunt field resistance is 220Ω. Calculate:

(i). the armature no load current,

(ii). the counter emf under no load,

(iii). the speed when the load current is 41A,

(iv). the speed regulation.

Q5, (20 pts): Fig. Q5-1 shows a cross-sectional sketch of a machine having a rotor winding f and two identical stator windings "a" and "b" with turns N whose axes are in quadrature. The uniform air gap between rotor and stator is "g", its equivalent cross-sectional area "Ag", and the material of the core $\mu \rightarrow \infty$. The stator windings are energized by a balanced two-phase currents:

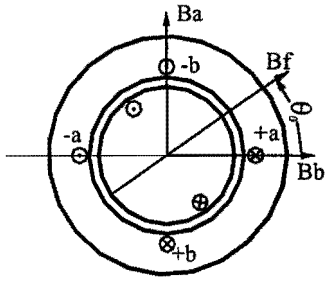

Fig. Q5-1

$$i_a = I_0 \cdot \sin \omega t \qquad i_b = I_0 \cdot \cos \omega t$$

(i). Derive the resultant flux density, B_{tt}, in the air gap.

(ii). Show the B_{tt} is rotating and its rotating direction CCW or CW.