National University of Computer and Emerging Sciences

Electro Mechanical Systems (EE2010)

Date: April 4th, 2024

Course Instructor(s)

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Sessional-2 Exam

Total Time: 1 Hours
Total Marks: 50
Total Questions: 02

Semester: SP-2024
Campus: Lahore
Dept: Electrical Engineering

Student Name _____ Roll No _____ Section _____ Student Signature _____

Vetted by _____ Vetter Signature _____

CLO #3: Analyze Synchronous Generator performance along with special emphasis towards environmental cost of generation

Q1: **[marks 25]**

A 2.6 KV, 1.25 MVA, 0.85-PF-lagging, 50-Hz, 16 pole, Y-connected synchronous generator, has a synchronous reactance of 1.2 Ω and an armature resistance of 0.2 Ω. At 50 Hz, its friction and windage losses are 26 KW, and its core losses are 22 KW. The field circuit has a dc voltage of 220 V, and the maximum I_F is 10 A. The resistance of the field circuit is adjustable over the range from 22 to 200 Ω.

The generator is running at rated conditions, find out the following quantities

a) Line current (5)
b) Rotational speed (5)
c) Voltage regulation (10)
d) Efficiency (3)
e) Output torque of prime mover (2)

I_F (A)	2	4	6	8	10
$V_{T,NL}$ (V)	1200	2200	2700	2850	2950

OCC for above generator

$I_L = \frac{S}{\sqrt{3}V} = \frac{1.25M}{\sqrt{3}\,2.6K} = 277.5A$

$n_s = \frac{120f}{P} = \frac{120\times 50}{16} = 375$ rpm

$P_{in} = P_{out} + P_{cu} + P_{f\&w} + P_{core}$
$= 1156.2$ KW

$\eta = \frac{1062}{1156.2} \times 100$

$\eta = 91.85\%$

$\tau = \frac{P_{out}}{\omega_m} = 2704.3$ Nm

$E_A = V_t + jX_s I_A + I_A R_A$
$= \frac{2.6k\angle 0}{\sqrt{3}} + j(1.2)(277.5\angle -31.8) + (0.2)(277.5\angle -31.8)$
$= 1501.1\angle 0 + (235.3 + 146.2j)(0.2 + j1.2)$
$= 1373.79 + 253.7j$ V

$I_L = 235.3 + 146.2j$

$P_{out} = \sqrt{3}\,V_t I_L \cos\theta$
$= \sqrt{3}(2.6k)(277.5)(0.85)$
$= 1062$ KW

$P_{cu,loss} = 3I_L^2 R_A = 462$ KW

$VR = \frac{E_A - V_t}{V_t} \times 100$
$= \frac{|1942.3| - |1501.1|}{|1501.1|}$
$= +0.1806\%$

$E_A = 1942.9\angle 8.3°$ V

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CLO #2: Investigate working of a DC Machine

Q2: [marks =25]

A 20KW, 240V compensated DC shunt motor has armature resistance of 0.4 Ω. Its field resistance is 100 Ω and adjustable resistance connected in series with field coil can vary from 50 Ω to 200 Ω. Its no load characteristic curve at a speed of 1500 rpm is tabulated as under.

I_F (A)	0.3	0.6	0.9	1.2	1.4	1.6
E_A (V)	130	230	274	288	292	295

Find out following quantities assuming rated terminal voltage in all cases.

a) No load speed of motor if adjustable resistance connected in series with field coil has been set to a value of 110 ohm.
b) The speed at a line current of 60A, with same field current as in part (a)
c) Fully labeled Circuit diagram for part (b)
d) Output torque in part (b) if mechanical and core losses are 700 watts
e) Maximum possible no load speed of the motor

$\uparrow \omega \propto \frac{1}{\Phi} \downarrow$.