MACHAKOS UNIVERSITY

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UNIVERSITY EXAMINATION 2017/2018

FIFTH YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING

EEE 508: POWER ELECTRONICS AND VARIABLE SPEED DRIVES

DATE: DECEMBER 2017 **TIME 2HRS**

INSTRUCTIONS: This examination paper contains five questions. Answer **Question ONE** and any other **TWO Questions**. Question ONE carries 30 Marks and ALL the other questions carry 20 Marks each.

QUESTION ONE(Compulsory)

a) The speed of a separately excited dc motor is controlled by a single phase full wave converter. The field circuit is also controlled by a full converter and the field current is set to the maximum possible value. The ac supply voltage to the armature and field converter is one phase, 440V, 60Hz. The armature resistance R_a=175 Ohm, and the motor voltage constant K_v=1.4V/A rad/s. the armature current corresponding to the

load demand I_a=45A. if the delay angle of the armature converter is α_a=60° and the armature current I_a=45A, determine

i) The torque developed by the motor T_d **[3Marks]**

ii) The speed ω **[3Marks]**

iii) Input PFof the drive **[3Marks]**

iv)

b) Show the four quadrants of operation of a dc motor on a Torque vs speed plane. On your diagram, show how V_a , I_a and E_a , are manipulated to achieve the operation of the motor in each of the four quadrants. **[3Marks]**

c) A separately excited dc motor has the following ratings: 100hp, 440V and 2000rpm.

i) Calculate the rated torque of the motor **[2Marks]**

ii) Calculate the current at rated output efficiency of the motor [**2Marks]**

iii) Explain how operation at speeds greater than base speed is achieved.**[2Marks]**

iv) Draw the Torque vs. Speed, Power vs. Speed, Armature voltage vs. Speed, Back emf vs. Speed, and Armature current vs. Speed envelopes for constant torque and constant power regions of operation of the motor.

[5Marks]

v) The dc machine above is connected across a 240V line and rotates at 1200rpm and is generating 230V with an armature current of 40A.Is the machine functioning as a generator or as a motor? Explain. **[1Marks]**

vi) Determine the resistance of the armature circuit in (iv) above. **[2Marks]**

vii) Determine the power loss in the armature circuit resistance and the electromagnetic power **[2Marks]**

viii) Determine the electromagnetic torque in Nm **[2Marks]**

QUESTION TWO

a) The speed of a 125hp, 600V, 1800rpm, separately excited dc motor is controlled by a 3Φ (ThreePhase) full converterThe converter is operated from a 3Φ, 480V, 60Hz supply. The rated armature current of the motor is 165A. The motor parameters are R_a=0.0874Ohms, L_a=6.5mH, and KΦ=0.33V/rpm. The converter and ac supply are considered to be ideal.

i) Find the no load speed at firing angles α=0deg, and α=30deg, assumethat, at no load, the armature current is 10% of the rated current and is continuous

ii) Find the firing angle to obtain the rated speed of 1800rpm at rated motor current

iii) Compute the speed regulation for the firing angle obtained in part (ii) above taking currents 10% of the rated. **[14Marks]**

b) The speed of a separately excited dc motor is controlled by a chopper. The dc supply is 120V, the armature circuit resistance $R_a = 0.5\ Ohms$, the armature circuit inductance $L_a = 20mH$, and the motor constant is KΦ=0.05V/rpm. The motor drives a constant-torque load requiring an average current of 20A. Assume that the motor current is continuous: Determine,

i) Range of speed control

ii) Range of duty cycle **[6Marks]**

QUESTION THREE

a) The speed of a 10hp, 220V, 1200rpm separately excited dc motor is controlled by a single phase full converter, the rated armature current is 40A. the armature resistance $R_a = 0.25\ Ohms$ and the inductance $L_a = 10mH$. The ac supply voltage is KΦ=0.18V/rpm. Assume that the motor current is continuous and ripple free, for a firing angle of 30deg, and rated motor current, determine the:

i) Speed of the motor **[4Marks]**

ii) Motor torque **[5Marks]**

iii) Power of the motor **[5Marks]**

b) A 230V DC shunt motor draws 25A while running at a speed of 600rpm. Armature resistance is 0.1 Ohm and the field resistance is 115 Ohm. Total rotational loss is 750Watts. Calculate:

i) Armature torque

ii) Overall efficiency of the motor **[6Marks]**

QUESTION FOUR

A separately excited dc motor has the following parameters

$R_a = 0.5\ ohm, \quad L_a \cong 0B \cong 0$

The motor generates an open circuit armature voltage of 220V at 2000rpm and with a field current of 1.0Ampere. The motor drives a constant load torque $T_L = 25\ N.m$ The combined inertia of the motor and load is J=2.5kg.m^2. With afield current $I_f = 1.0A$, The armature currents are connected to a 220V dc source.

i) Derive an expression for speed (w_m) and the armature current (i_a) as a function of time. **[16Marks]**

ii) Determine the steady-state values of the speed and armature current **[4Marks]**

QUESTION FIVE

a) A 150kW, 460V, 3-phase 3520r/min, 60Hz induction motor has a locked-rotor torque of 600N.m and a locked rotor current of 1400A. Three resistors are connected in series with the line so as to reduce the voltage across the motor to 0.65p.u.

Calculate:

i) The apparent power absorbed by the motor under full-voltage, locked conditions. **[2Marks]**

ii) The apparent power absorbed by the motor when the resistors are in the circuit. **[4Marks]**

iii) The apparent power drawn from the line, with the resistors in the circuit **[4Marks]**

iv) The locked-rotor torque developed by the motor **[2Marks]**

b) A standard 3-phase, 10hp, 575V, 1750r/min, 60Hz NEMA class D squirrel cage Induction motor develops a torque of 110 N.m at a speed of 1440r/min. If the motor is excited at a frequency of 25Hz, Calculate:

i) The squirrel voltage to maintain the same flux in the machine**[2Marks]**

ii) The new speed at 110N.m **[6Marks]**