UNIVERSITY OF SWAZILAND

SECOND SEMESTER EXAMINATION 2006/2007

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

TITLE OF PAPER: ELECTRONICS 4

COURSE NUMBER: E512

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1.   Answer any <u>FOUR</u> (4) of the following six questions.

2.   Each question carries 25 marks.

3.   If you think not enough data has been given in any question you may assume reasonable values.

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THIS PAPER CONTAINS FOUR (4) PAGES INCLUDING THIS PAGE

QUESTION 1

(a) A machine shop is fed by a 300 kVA, 400 V, three-phase transformer bank that has a load consisting of many small motors. The total shop load is 225 kVA and the power factor is 0.74 lagging.

    (i)   What is the line current in the feeder from the transformer to the facility?

                [3 MARKS]

    (ii)   The shop owner would like to expand the services provided to the customers. This requires adding two 50 HP motors that will run at rated load. One possibility is to use synchronous motors and run them at a 0.8 leading power factor. The synchronous motors are 94% efficient. Would the total load fit within the size of the existing service?

                [12 MARKS]

(b) A machine shop has a three-phase electrical load consisting of many small motors. The total shop load is 250 kVA and the power factor is 0.76 lagging. The utility would like them to improve their power factor to greater than 0.93 lagging, but they must keep a lagging power factor. How many kVARs of capacitors will they require to achieve the minimum power factor?

                [10 MARKS]

QUESTION 2

(a)   A three-phase, Y-connected, 400 V, 1460 RPM, 100 HP induction motor has the following equivalent circuit parameters per phase: $R_s = 0.065 \ \Omega$, $R_r = 0.05 \ \Omega$, $X_s = 0.65 \ \Omega$, $X_r = 0.84 \ \Omega$, $X_m = 16.5 \ \Omega$.

    (i)   Calculate the no-load current (assume $n_r = n_s$ at no-load).

                [5 MARKS]

    (ii)   Calculate the line current when the motor develops rated KW at rated speed.

                [10 MARKS]

(b)   A 3-phase induction motor is rated 50 HP, 50 Hz, 400 V, four pole. When operating at rated conditions, $\eta = 89.6\%$, $F_p = 0.8$, $s = 3\%$. If the motor is operated at 45 Hz, 360 V, and $n_r = 1310$ RPM, what is the approximate developed HP?

                [10 MARKS]

QUESTION 3

(a) The electrical specifications of a 230 VAC, 50 Hz, split-phase induction motor are as follows: $R_{mw} = 3\ \Omega$, $R_{aw} = 12\ \Omega$, $X_{mw} = j12\ \Omega$, $X_{aw} = j10\ \Omega$.

    (i)   Calculate the magnitude and angle of the starting or locked-rotor current.

    [7 MARKS]

    (ii)   Calculate the phase angle between I_{mw} and I_{aw}.

    [2 MARKS]

    (iii)   Specify a capacitor that, when added to the auxiliary winding, will cause the motor to develop maximum starting torque.

    [8 MARKS]

(b)

    (i)   What is the disadvantage of full-voltage starting of three-phase induction motors?

    (ii)   What is the disadvantage of reduced-voltage starting of three-phase induction motors?

    (iii)   Name four methods of reduced-voltage starting of three-phase induction motors.

    [8 MARKS]

QUESTION 4

(a)   A 2930 RPM, three-phase, 50 Hz, 400 V, 100 HP induction motor is to be operated from an adjustable frequency drive.

    (i)   What should the dc bus voltage be?
    (ii)   What is the approximate operating speed at 35 Hz?
    (iii)   What is the rated HP at 35 Hz?

    [15 MARKS]

(b)   A stepper motor has 6 stator poles, a total of 36 teeth on the stator and 32 teeth on the rotor. The motor is connected to a screw drive on a machine tool. The screw has 32 threads that span 2.56 mm. If the motor is commanded to move 25 steps, how far does the machine tool move?

    [10 MARKS]

QUESTION 5

(a) A three-phase synchronous generator is connected to an infinite bus at 11 KV (line-to-line), 50 Hz. The generator has a synchronous reactance of 1.5 Ω per phase and negligible armature resistance. The generator real power is measured as 55 MW and the reactive power out of the generator is 23.5 MVAR (i.e., the generator is operating in a lagging condition).

    (i)   Find the internal generated voltage and power angle.

    (ii)   Draw a phasor diagram showing the terminal voltage as the reference voltage, the generated voltage, the armature current, and the voltage drop across the synchronous reactance.

[15 MARKS]

(b) A three-phase synchronous motor is rated 100 HP, 400 V, 0.9 power factor. It operates at rated conditions and is 94% efficient. The synchronous reactance is 4.5 Ω per phase. Find the line current and the back emf, assuming the motor operates at a leading power factor.

[10 MARKS]

QUESTION 6

(a) A shunt field DC motor is rated 15 KW, 240 V, 2700 RPM, and draws 75 A when operating at rated conditions. The field rheostat is adjusted so that the stator flux per pole is reduced by 10%, and the load is adjusted so that the armature current is 60A. Find the new operating speed of the motor. The shunt field has a resistance of 80 Ω, and the armature winding has a resistance of 0.2 Ω.

[17 MARKS]

(b) A six-pole DC generator has 456 conductors in the slots of the armature, which is lap wound. The flux per pole is 0.01 Wb, and the machine is driven at 2400 RPM. What is the generated voltage?

[8 MARKS]