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END SEMESTER EXAMINATION -WINTER 2022-23

Date: 18-04-2023 Time: 2.00PM-5.00PM

EE6306 POWER ELECTRONIC DRIVES

(Answer all questions. Make suitable assumptions wherever necessary)

Max. Marks: 50

1. Fig. 1 below shows a belt conveyor drive system which is used to move load X which has a mass of 5 kg. Given that the frictional torque between the rollers and the belt is 25 Nm and the moment of inertia of the rollers and motor are 0.25 kg-m^2 and 0.3 kg-m^2 respectively. The radius of the roller is 0.2 m. The steady state speed of the motor is 1000 rpm and it is required that the steady state speed of box X to be v = 3 m/s.
   i. What is the required gear ratio?
   ii. What is the equivalent moment of inertia as seen by the motor shaft?
   iii. What is the equivalent load torque as seen by the motor shaft?
   iv. Calculate the electrical torque needed to accelerate box X from 0 m/s (standstill) to 3 m/s in 2 second.

   (5 Marks)

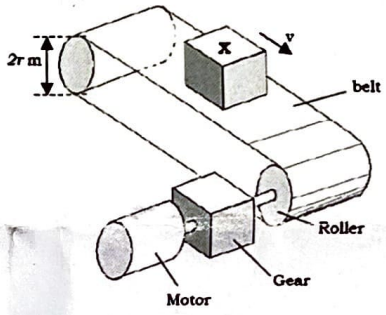

Fig. 1

2. A Motor drive four loads, two have rotational motion and two have translational motion. Moment of inertia of the motor is 1.2kg-m^2 and the motor runs at a speed of 1000rpm.

Load	Type of motion	Speed	Inertia / Mass	Torque / Force
1	Rotational	200 rpm	7 kg-m^2	10 Nm
2	Translational	10 m/s	10 kg	20 N
3	Rotational	200 rpm	5 kg-m^2	6 Nm
4	Translational	10 m/s	20 kg	30 N

Calculate the equivalent moment of inertia of the system referred to the motor shaft and the power rating of the motor, assuming negligible losses in the transmission system. (5 Marks)

3. A motor having a suitable control circuit develops a torque given by the relationship $T_d = u\omega + v$, where u and v are positive constants. This motor is used to drive a load whose torque is expressed as $T_L = x\omega^2 + y$, where x and y are some other positive constants. The total inertia of the rotating masses is J.
   a) Determine the relations amongst the constant u, v, x and y in order that the motor can start together with load and have an equilibrium operating speed?
   b) Calculate the equilibrium operating speed?
   c) Will the drive be stable at this speed?
   d) Determine the initial acceleration of the drive? (5 Marks)

4. The speed of a separately excited DC motor is controlled using two single-phase full converters, one in the armature circuit and the other in the field circuit and both are fed from a single-phase 250 V, 50 Hz sources. The armature and field resistances are 0.2 Ω and 180 Ω respectively. Field converter has a firing angle delay of 0^0. With magnetic saturation neglected, the motor constant is 1.2 V.sec./(A. rad). The motor drives a rated load torque of 75 Nm at 900rpm. The armature and field currents are continuous and ripple free. Determine a) the rated armature current, b) the firing angle delay of armature converter at rated load and c) the speed of operation of the motor when the load is suddenly removed. (5 Marks)

5. A chopper is used to control the speed of a separately excited motor. The DC supply voltage is 220V, armature resistance R_a is 0.2 Ω and motor constant 0.08 V/rpm. The motor drives a constant torque load requiring an average armature current of 15 A. Assume the motor current to be continuous. Determine (a) the range in which speed can be controlled, and (b) corresponding range of duty cycle. (5 Marks)

6. A DC series motor used for a rapid transit system is fed through a DC chopper. The series motor has total circuit resistance of 2 Ω and inductance of 1.5 mH. What external inductance should be inserted in series with motor armature circuit in order to limit the per unit ripple in armature current to 10% for a duty ratio of 0.5? The chopping frequency is 1 kHz. (5 Marks)

7. a) A 400V, 50Hz Star connected Induction motor is fed from a six step inverter which in turn fed from a six-pulse fully controlled rectifier. The a.c. supply mains are rated at 440V, 50Hz. What should be the firing angle of the rectifier to operate the motor at 50 Hz under v/f control? (2 Marks)

   b) A 460-V, 25-hp, 60 Hz, four-pole, Y-connected induction motor has the following impedances in ohms per phase referred to the stator circuit:

   $R_1 = 0.641\Omega$; $R_2 = 0.332\Omega$; $X_1 = 1.106\Omega$; $X_2 = 0.464\Omega$; $X_M = 26.3\ \Omega$

   The total rotational losses are 1100 W and are assumed to be constant. The core loss is lumped in with the rotational losses. For a rotor slip of 2.2 percent at the rated voltage and rated frequency, find the motor's

   a) Speed
   b) Stator current
   c) Power factor
   d) Efficiency

   (3 Marks)

8. a) Find the efficiency of an Induction Motor operating at full load. The machine details are given below:

   1000HP, 1200V, 3 Phase, Star connected, 4 pole, 50Hz, Full load slip = 0.025,

   $R_s = 0.025\Omega$; $R_r = 0.01\Omega$; $R_c = 400\Omega$; $X_m = 50\Omega$; $X_{ls} = X_{lr} = 0.3\Omega$

   (3 Marks)

   b) The line power factor needs to be improved to unity by installing capacitors at the input terminals of the induction motor. Calculate per-phase capacitance required to obtain a line power factor of unity. (2 Marks)

9. A two-level Voltage Source Inverter (VSI) is used to drive a 3-phase Induction Motor whose ratings are as follows:

   5 HP, 400V, 50Hz, 3-phase, 4-pole, Star connected

   a) Calculate the DC bus voltage required for the two-level VSI to drive the Induction Motor in the entire speed range? (2 Marks)
   b) If SVPWM is used in the inverter, calculate the magnitude of the reference voltage vector to be generated to run the induction motor at 1200 rpm? (2 Marks)
   c) Calculate the active and zero vector switching times for the above case at when reference voltage vector is at an angle of 30^0. (3 Marks)

10. Draw the block diagram of vector controlled IM drive fed from voltage controlled VSI. (3 Marks)

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