Name: Parvil P P

NATIONAL INSTITUTE OF TECHNOLOGY, CALICUT
DEPARTMENT OF ELECTRICAL ENGINEERING
MID SEMESTER EXAMINATION –WINTER 2022-23

Date: 22-02-2023 Time: 2.00PM-4.00PM

EE6306D POWER ELECTRONIC DRIVES

(Answer all questions. Make suitable assumptions wherever necessary)

Max. Marks: 35

1. Obtain the equilibrium points and determine their steady stability when motor and load torques are: $T_e = -1-2\omega_m$ and $T_l = 3\omega_m^{0.5}$ (5 Marks)
2. A motor equipped with flywheel has to supply a load torque of 750 Nm for 15sec. followed by a no load period long enough for the flywheel to regain its full speed. It is desired to limit the motor torque to 375 Nm. What should be the moment of inertia of the flywheel? The no-load speed of the motor is 750 rpm and it has a slip of 6% at 300 Nm. Assume the motor speed-torque characteristic to be a straight line in the range of operation. Motor has a moment of inertia of 15 kg-m^2. (5 Marks)
3. An electrical drive system shown in Fig. 1 can be described by the following torque equation: $T_e - T_l = J\frac{d\omega_m}{dt}$ where J is the moment of inertia of the combined motor and load, T_e is the electrical torque, T_l is the load torque and ω_m is angular speed of the rotor. The moment of inertia J is found to be 0.12 kg-m^2. (a) What would be the electrical torque needed to accelerate the rotor to reach the desired speed of 100rad/s in exactly 1 second, if the load torque T_l=20Nm? (b) For the same electrical torque calculated in (a), how long it will take to accelerate to 100rad/s if the load torque is T_l=20+0.1ω_m? In order to reach 100rad/s in 1 second, what should be the applied electrical torque? (5 Marks)

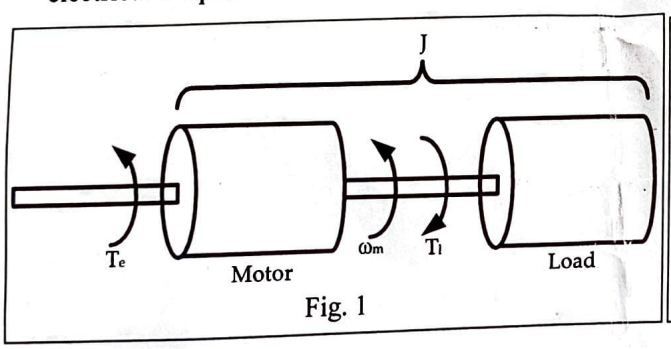

Fig. 1

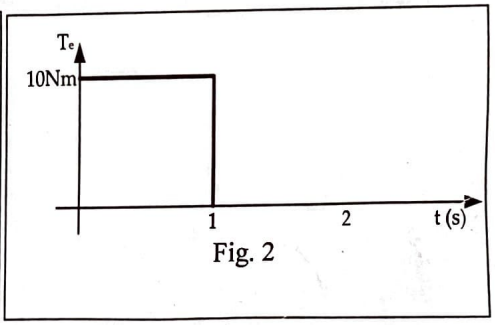

Fig. 2

4. If the torque produced by the motor is as shown in Fig. 2, sketch and describe the speed response of the system shown in Fig. 1, for following load torque: (a) $T_l = 0$, (b) $T_l = 2$ Nm, and (c) $T_l = 1.5\omega_m$ Nm. Sketch the response for $0 < t \leq 2s$ and assume that the speed at $t = 0$ is zero. Given J = 0.1kg-m^2. (5 Marks)
5. A separately excited DC motor is rated at 10kW, 240V, and 1000rpm is supplied from a single-phase full converter. The input supply to the converter is 240V, 50Hz. The motor armature resistance is Ra=0.42Ω and the motor constant is 2 V/rad/sec. Some additional inductance is included in the armature circuit to ensure continuous conduction but its value is unknown. Calculate the speed and efficiency of operation of the motor for firing angles $\alpha=0^0$ and $\alpha=20^0$ if load torque is kept constant at rated value. (5 Marks)

6. A separately excited DC motor has an emf constant 1.2 V sec./rad. The motor is controlled by variation in armature voltage. The resistance and inductance of the armature are 0.5Ω and 0.2H. The inertia of the motor and coupled load is 0.5kg-m^2. The coefficient of viscous damping is 0.05 Nm/rad/sec. Determine

   a) the transfer function relating motor speed to armature applied voltage. (2 Marks)

   b) the step response when a voltage of 20V is applied to the motor which is at rest. (3 Marks)

7. The parameters and ratings of a separately excited DC motor are as follows:
   200V, 7.5A, 1450rpm, R_a=3 Ω, L_a=60mH,
   J=0.075 kg-m2, B_t = 0.09 Nm/rad/sec. & K_b=1.3 V/rad/sec.
   The converter is supplied from 400V, 3φ AC supply at 50Hz. The converter is linear, and its maximum control input voltage is ±10V. The speed reference voltage has a maximum of 10V. The maximum current permitted in the motor is 20A. The tacho generator has the transfer function

$$G_r(s) = \frac{0.065}{(1 + 0.002s)}$$

   Calculate

   a. Converter transfer function,
   b. Current transducer gain,
   c. Motor transfer function, and
   d. Current controller gain and time constant. (5 Marks)

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