Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
Mid Term Exam. (Spring) 2011-2012

Electric Drives (EE40002) — Total Marks: 60
4th year B.Tech EE — 37 Students
Time: 2 hours

Instructions: This question paper has **FIVE** questions. Attempt **ALL** the questions. Make necessary assumptions wherever required.

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1) (a) An induction motor has the torque speed characteristic given by $T_d = \frac{2T_{max}}{\frac{S}{S_{max}} + \frac{S_{max}}{S}}$ where, S=Slip, S_{max}=Slip at which maximum torque takes place, T_d=Torque developed by the motor and T_{max} = Maximum torque developed by the motor. Take $T_{max}=1.5p.u.$ and $S_{max}=0.2p.u.$ The motor drives a constant load torque of 0.5p.u. Determine the corresponding equilibrium speeds and evaluate their steady state stability with proper mathematical justification. **[6]**

(b) A horizontal conveyer belt moving at a uniform speed of 1.2m/s transports material at the rate of 10^5kg/hour. Belt is 200m long and is driven by a motor at 1200rpm. It can be assumed that the material is distributed evenly on the belt surface. Frictional losses can be neglected.
(i) Determine the load inertia referred to the motor shaft. **[3]**
(ii) Calculate the torque that the motor should develop to accelerate the belt from standstill to full speed (1.2m/s) in 8 sec. Moment of inertia of the motor is 0.1kg-m^2. **[3]**

2) An electric motor drive is used for a variable load duty-cycle. The temperature-rise of the motor is 40^0C after one hour of continuous operation and 60^0C after two hours of continuous operation at rated load. Heating and cooling time constants can be assumed to be same. The losses in the motor can be assumed to be proportional to the square of the loading.
(i) Determine the steady-state temperature-rise of the electric motor for continuous operation at rated load. **[4]**
(ii) The motor is subjected to a periodic variable load-cycle of 10 minutes working at 125% of its rated load followed by 20 minutes of shut-down. Determine the corresponding maximum and minimum temperature-rise under steady-state condition. **[4+4]**

3) A 220V, 1500 rpm, 10A separately excited DC motor is fed from a controlled power converter. The armature resistance and the inductance of the DC motor are 2Ω and 50mH respectively. Assume that the field current is maintained constant at its rated value. Feed forward compensation for back emf is provided for achieving faster dynamic response. The power converter can be considered to be a unity gain block and the current and speed feedback paths can be assumed to have no delay.
(i) Design the PI controller parameters for armature current control such that the current control bandwidth is 100Hz ($2\pi\times100$ rad/sec). **[5]**
(ii) Design the PI controller parameters for speed control such that the speed loop zero crossover frequency is 10Hz ($2\pi\times10$ rad/sec) with the phase margin at the zero crossover frequency to be 60^0. **[7]**

4) A 230V, 1000rpm, 30A separately excited DC motor is fed from a two quadrant chopper. Assume that the field current is maintained constant at its rated value. The armature resistance and the inductance of the DC motor are 0.7Ω and 50mH respectively. Motor is controlled in regenerative braking by the chopper operating at 800Hz from a DC source of 230V.

(i) Calculate duty ratio of chopper for rated torque and speed of 800rpm during regenerative braking. **[4]**

(ii) Determine the steady state minimum and maximum values of armature current assuming the speed to be constant at 800rpm. **[4+4]**

5) A 230V, 960 rpm, 20A separately excited DC motor has armature resistance and inductance of 1.2Ω and 50mH respectively. Motor is controlled by a single phase half controlled rectifier with source voltage of 230V, 50Hz. The firing angle $\alpha=90^0$.

(i) Calculate the no load speed. **[3]**

(ii) Calculate the speed at which the motor will run while delivering rated load current. **[3]**

(iii) Calculate the speed and the developed torque at the boundary between the continuous and discontinuous conduction mode. **[3+3]**