Department of Mechanical, Materials and Manufacturing Engineering

The University of Nottingham

Computer Engineering and Mechatronics MMME3085

Solution sheet 7: Stepper motor dynamics

1. 25 rev/s is 25×360/1.8=5000 steps per sec. Need at least 0.2×2=0.4 Nm Of the motors described, type 300 can just supply the torque required.

2. a) Moment of inertia referred to motor is $J'=mr^2 = 0.5\times0.011^2 = 0.0000605$ kg m^2 but motor inertia is 2.5×10^{-5} kg m^2 so total inertia is $J_{total} = J' + J_{motor} = 0.0000605 + 2.5\times10^{-5} = 0.0000855$ kg m^2.

   b) Maximum torque is $J_{total}\times\langle + L_{fric} = 3636\times0.0000855 + 0.01619 = 0.3109 + 0.01619 = 0.327$ Nm. So the 200 size motor is not quite up to the job, even with no factor of safety applied. Even the 300 size won't be quite enough, so consider using a larger motor still, or see if the acceleration specification can be relaxed.

3. a) Total inertia which must be accelerated by motor is $J_{total} + J_{motor} = 1.0205 \times 10^{-5} + 8\times10^{-6} = 1.1005\times10^{-4}$ kg m^2

   b) Trial and error. Try 1s: ring must move 90° in 0.5s, so motor must rotate by $9=(90/360)*16 = 4$ revolutions $= 8\mu$ rad in 0.5s, starting from rest. This requires an angular acceleration of $\langle=2\mathcal{9}/t^2 = 2\times8\mu/(0.5^2) = 201.1$ rad/s^2

   Maximum speed is $201.1\times0.5 = 100.5$ rad/s = 16 rev/s requiring 3200 steps/s. Torque available is 0.17 Nm

   Torque required is $201.1\times1.1005\times10^{-4} = 0.022$ Nm, so no problem at all.

   Try 0.6s: ring must move 90° in 0.3s, so motor must rotate by $9=(90/360)\times16 = 4$ revolutions $= 8\mu$ rad in 0.3s, starting from rest. This requires an angular acceleration of $\langle=2\mathcal{9}/t^2 = 2\times8\mu/(0.3^2) = 558$ rad/s^2

   Maximum speed is $558\times0.3 = 167.4$ rad/s = 26 rev/s requiring 5328 steps/s. OK.

   Torque required is $558\times1.1005\times10^{-4} = 0.06$ Nm. Available torque is about 0.12 Nm so OK, a factor of safety of around 2.

Try 0.55s: ring must move 90° in 0.275s, so motor must rotate by $\theta = (90/360) \cdot 16 = 4$ revolutions $= 8\mu$ rad in 0.275s, starting from rest. This requires an angular acceleration of $\alpha = 2\theta/t^2 = 2 \cdot 8\mu / (0.275^2) = 664$ rad/s^2

Maximum speed is $664 \cdot 0.275 = 182.8$ rad/s = 29.1 rev/s requiring 5818 steps/s. Still OK (just!).

Torque required is $664 \cdot 1.1005 \cdot 10^{-4} = 0.073$ Nm. Available torque is about 0.1 Nm so still OK, a factor of safety of around 1.3, probably a bit low.