Kon – 41.3140 Final exam 15.12.2014

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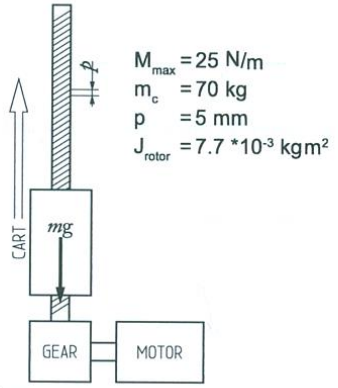
1. An incremental encoder is attached to a shaft, the speed of the shaft varies, but is at maximum ω_{max} = 1200 rpm. The sampling rate of your sensor system is at max 1000 samples per second.
   - **(a)** You need to be able to calculate the speed within 1 rpm at nominal speed of 600 rpm, in each half second interval. How many pulses does the encoder need to provide per revolution? (2p)
   - **(b)** Is your sampling rate sufficient? (1p)
   - **(c)** Would there be any benefit from an absolute encoder in this case? Motivate shortly. (1p)
   - **(d)** Outline a procedure for deriving rpm out of the signal in a micro controller. Describe how it would be done, you can use diagrams or pseudo code. (2p)

2. A system with a vertical leadscrew is depicted below. The system needs to be optimized in terms of linear acceleration of the cart when moving upwards. You do not need to account for the friction.

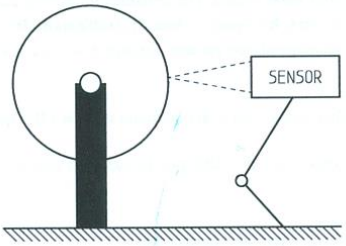


$M_{max} = 25$ N/m
$m_c = 70$ kg
$p = 5$ mm
$J_{rotor} = 7.7 * 10^{-3}$ kgm^2

Answer following:

- **(a)** The optimal linear acceleration. (2p)
- **(b)** The optimal gear ratio. (2p)
- **(c)** Describe in your own words what would change if the system would be changed to a counter balanced pulley system like the elevator. Is this beneficial? What advantages and what disadvantages does it have? (2p)
- **(d)** Calculate the optimal linear acceleration of a counter balanced pulley system where the pulley diameter is 50 mm. Using same motor and mass to lift. (2p)

3. The roll surface of a paper making machine roll is studied with a optical sensor that measures roll surfaces radial-runout. Roll's radial-runout is ±0.5 mm, and moves with the function $\mathbf{f(\theta) = 0.5\ Sin[3\theta]}$ (mm) where theta is the angle of the roll. Unfortunately the sensor's mounting vibrates with a 0.2 mm amplitude and has a phase difference of pi/2 to compared to θ. This is compensated by attaching an acceleration sensor to the mounting of the optical sensor. The system has a 10-bit analog-to-digital converter. The optical sensor can measure distances of ±3 mm, sensor's error at full range is 1%.



(a) What is the resolution of optical sensor? (1p)

(b) What would be a sufficent range for the optical sensor? (2p)

(c) Plot the movement sensor in relation to the roll. (1p)

(d) What should be the acceleration sensors accuracy be, so that the rolls surface error can be read at ±10 μm accuracy? (2p)

Formulas

Force along leadscrew on mass, as momentum. M_{fl} is the momentum generated, F the force on mass and p the pitch.

$$M_{fl} = F\,\frac{p}{2\,\pi}$$

Reduced innertia J_{red} of mass on leadscrew where p the pitch and m_l the mass on the leadscrew.

$$J_{red} = m_l\left(\frac{p}{2\,\pi}\right)^2$$