LAB REPORT

Lab 2: Familiarization with Equipment and Basic Cruise Control Design

Lab Date: 11/12/2019

Submission Date: 11/25/2019

Prelab: 1 marks

Lab Report: 4 marks

Lab Work: 5 marks

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4.2 Identification of model parameters

(0.25 mark) Find the relationship between the parameters *a* and *b*:
(Provide a derivation of this relationship based on your experimental observations)

$$a = 0.155b$$

(0.25 mark) The values of *a* and *b* found experimentally are: a = 1.55 b = 10

4.3 Proportional Control

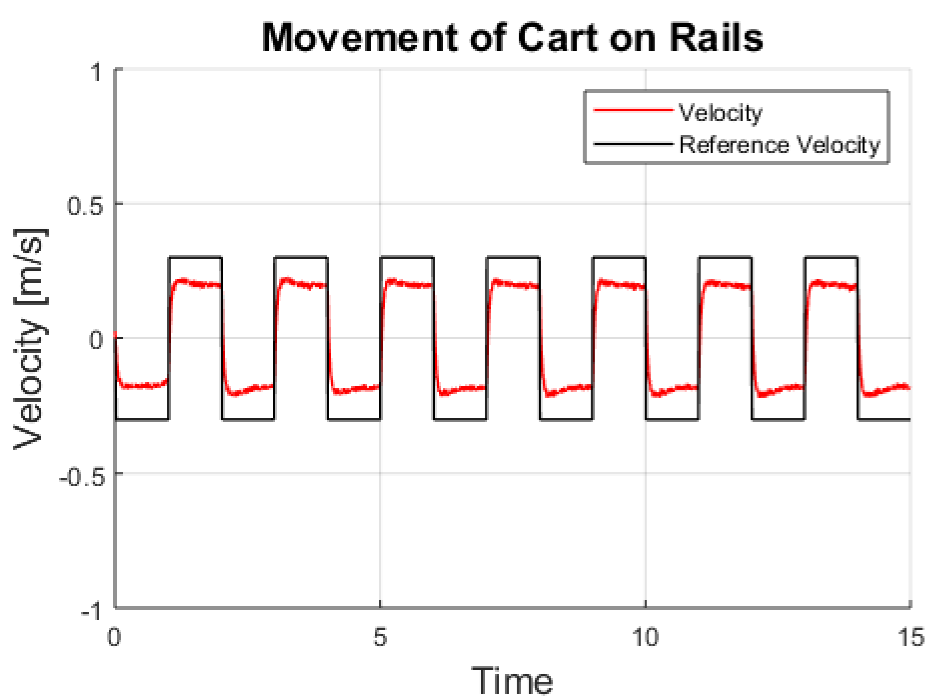
(0.25 mark) Does the P controller successfully regulate the speed to the desired value?

No, it did not regulate the speed to the desired value. The measured velocity is slightly lower than the reference velocity even when K increases. Furthermore, the measured velocity doesn't have a proper square wave shape, as its magnitude decreases slightly after reaching its peak.

(1 mark) What's the effect of increasing the gain K on the output response? Explain what is, in your opinion, the reason for the effect you have observed.

The measured velocity approaches the desired value as K increases. The output $V(s) = \frac{V_0}{s} \times \frac{a}{s+b}$ and $E(s) = \frac{V_0(s+b)}{s(Ka+s+b)}$. Using the FVT, we can solve for the steady state value of the error as $e_{ss} = \frac{V_0 b}{Ka+b}$. Thus, we can see that the steady state error decreases as K increases.

(0.75 mark) Plot the "P controller" experimental results; containing the measured velocity and the reference signal (with proper labels).



4.4 Proportional-Integral Control

(1.25 mark) How does the performance of the P and PI controllers compare? Explain the differences you observe and explain what is the reason for such differences?

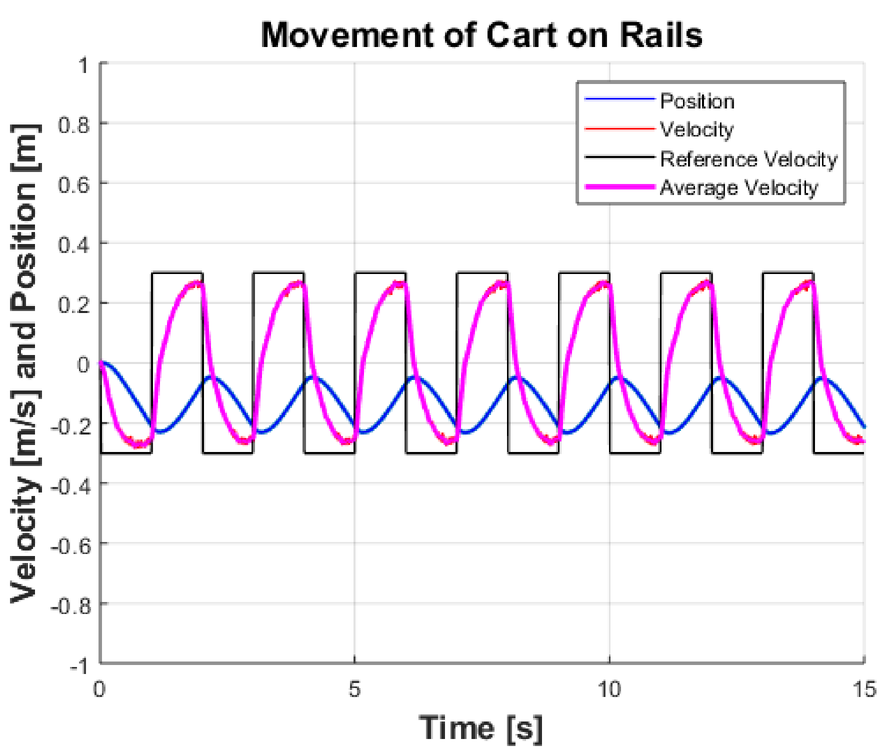
The PI controller performs better than the P controller for any value of K. For the PI controller, the steady state error reduces to zero for any value of K while in the P controller, the steady error only approaches 0 as k approaches infinity. This is because the integral part in the PI controller eliminates the steady state error because $E(s) = \frac{T_i V_o}{T_i s + K(T_i s + 1)}$ so $e_{ss} = 0$ from the FVT. While for a P controller, $e_{ss} = \frac{V_0 b}{Ka + b}$. So, the PI controller can successfully regulate the speed to the desired value.

(0.5 mark) What's the effect of increasing the gain K?

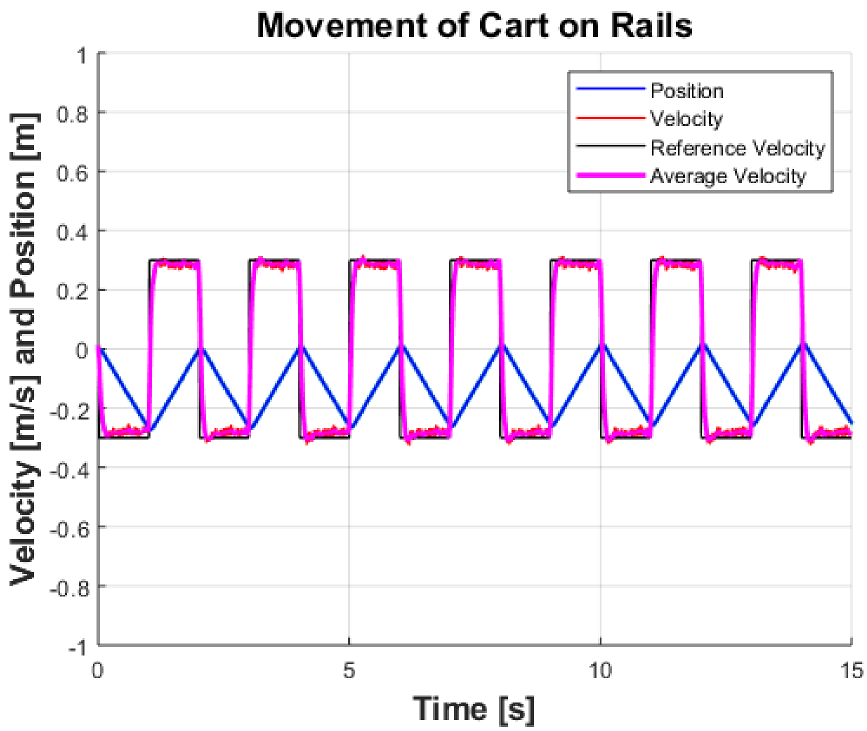
For the PI controller: $E(s) = \frac{T_i V_o}{T_i s + K(T_i s + 1)}$. Using the FVT we get $e_{ss} = e(\infty) = 0$ for any value of K. So, no matter what value of K we choose the steady state error will approach 0. However, as we increase K, the time taken to reach the steady state decreases, thus resulting in better tracking of the reference signal. Higher values of K results in a slight overshoot of average velocity compared to the reference velocity.

(0.75 mark) Plot the "PI controller" experimental results; containing the measured velocity and the reference signal (with proper labels).

<u>When K=2</u>



When K=20


Movement of Cart on Rails
Position
Velocity
Reference Velocity
Average Velocity
Velocity [m/s] and Position [m]
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
5
10
15
Time [s]