Project 4

Kyle Jeffrey

Abstract—The purpose of this project is to tune and test a PI Feedback Controller for the velocity and turning rate of an e-puck robot. The Robot is simulated and tested in VRep.

1 Introduction

The Block Digram shown in figure 1 depicts the turning rate and velocity of the e-puck differential drive robot, controlled by two PI controllers.

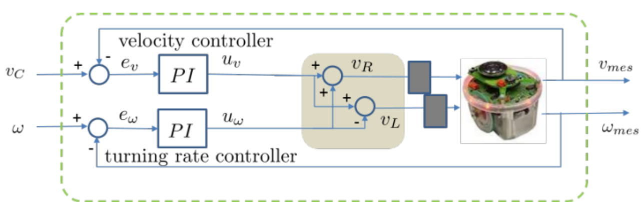

Fig. 1. Block Diagram w. PI Controllers

2 Tuning Kp Value for Turning Rate

The block diagram for the turning rate of the differential drive robot is shown in figure 2: I

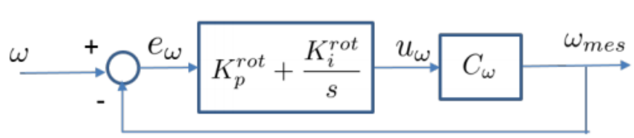

Fig. 2. Block Diagram w. PI Controllers

attempted to keep the integral value $K_i = 0$ to see how closely just using a proportional controller could be to tracking the reference input. Below are two graphs of the output showing the best K_p could get to tracking and how instability could arise at too high of a K_p value. Notice that strictly using a proportional controller, the reference signal isn't able to be reached. Using a Final Value theorem analysis of the system using a step-input, as the input we use is a step motor, we can see why the Proportional Controller will never reach the reference input.

$$e = \omega_{ref} - \omega = \omega_{ref}(1 - H(s)) \quad (1)$$

$$e = \omega_{ref}(1 - \frac{K_p C_\omega}{1 + K_p C_\omega}) \quad (2)$$

$$\lim_{s \to 0}(s)(\frac{1}{s})(1 - \frac{K_p C_\omega}{1 + K_p C_\omega}) = (1 - \frac{K_p C_\omega}{1 + K_p C_\omega}) \quad (3)$$

The end behavior of the system shows that the error of the system will never reach 0. Theo-

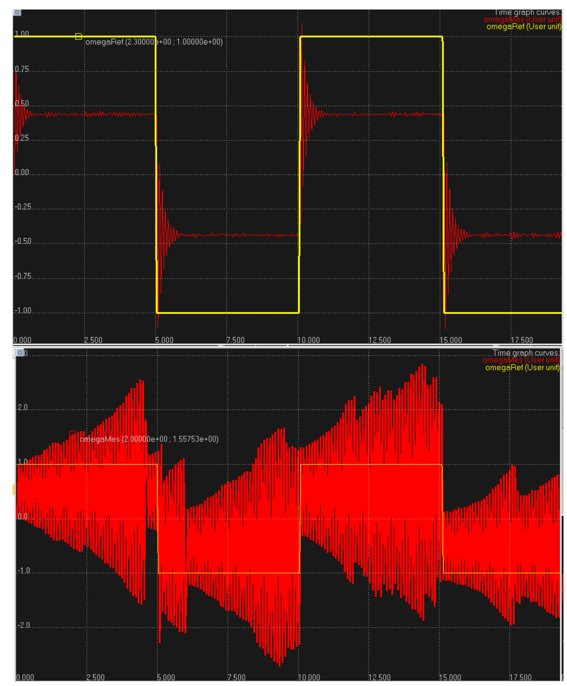

Fig. 3. Response With K_p = 1 (top), K_p = 1.3(bottom)

retically, as the K_p value gets higher, it should approach 0 but as shown in the graph above this doesn't end up being the case. A Routh Analysis, and Root Locus analysis should be done to determine the limits of K_p.

3 Tuning Ki Value for Turning Rate

Using the same feedback system, the K_i value is now investigated. It's apparent that the in-

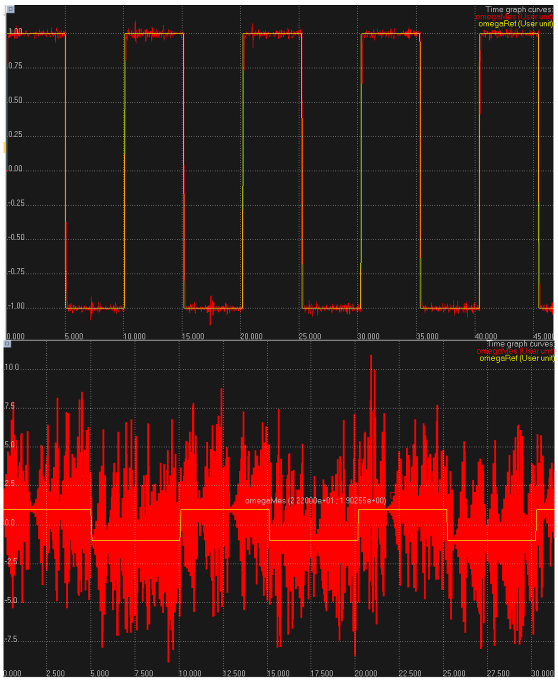

Fig. 4. Response With K_i = 20 (top), K_i = 60(bottom)

tegral feedback is much better at following the reference input. I found that leaving the proportional controller at zero feedback was the best way to track the reference input.

4 Tuning K Values for Tracking Velocity

Using the same procedure as was used for finding good K values for tracking the turning rate, the same is applied to the Velocity Feedback Controller, Below is a graph of the best values found:

For this controller, it appeared that a very high Integral Feedback was beneficial for the system. Whether or not an actual implementation of this would work with such a high feedback

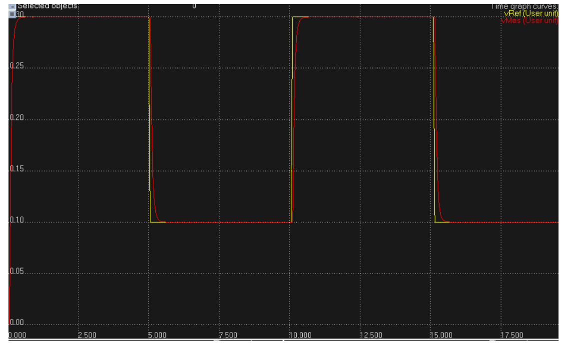

Fig. 5. Response With K_i = 500 , K_p = 0

is unknown to me. Again though, the Proportional Feedback doesn't appear to do much for the system, and was left at 0.

5 Adjust Turning to Achieve a Figure 8

With velocity set constant at .1, a figure eight shape of the motion of the robot was desired. Tuning the omega with step functions, the graph below shows the turning rate input and the subsequent path of the robot. This was acquired through simple trial and error.

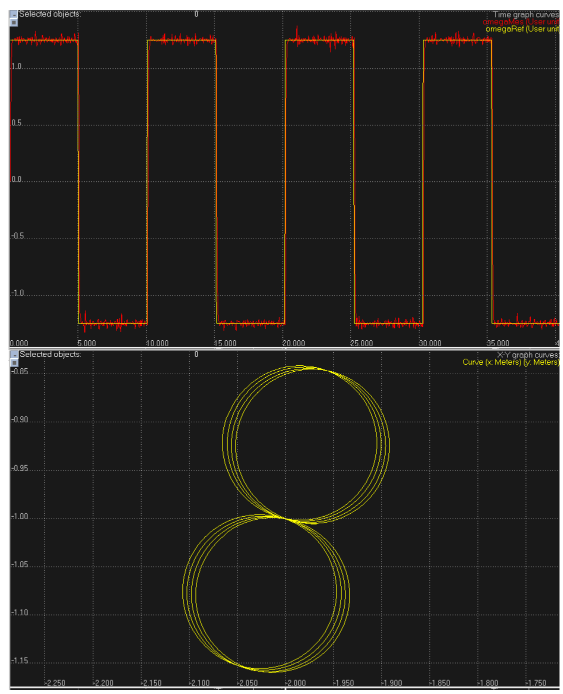

Fig. 6. Robot Figure 8

Kyle Jeffrey is a Senior Robotics Engineering Student at the University of California Santa Cruz. He is the Secretary of the Engineering Fraternity Tau Beta Pi and the lead Hardware Engineer at the on campus startup Yektasonics.