Mini Project: Matlab Documentation

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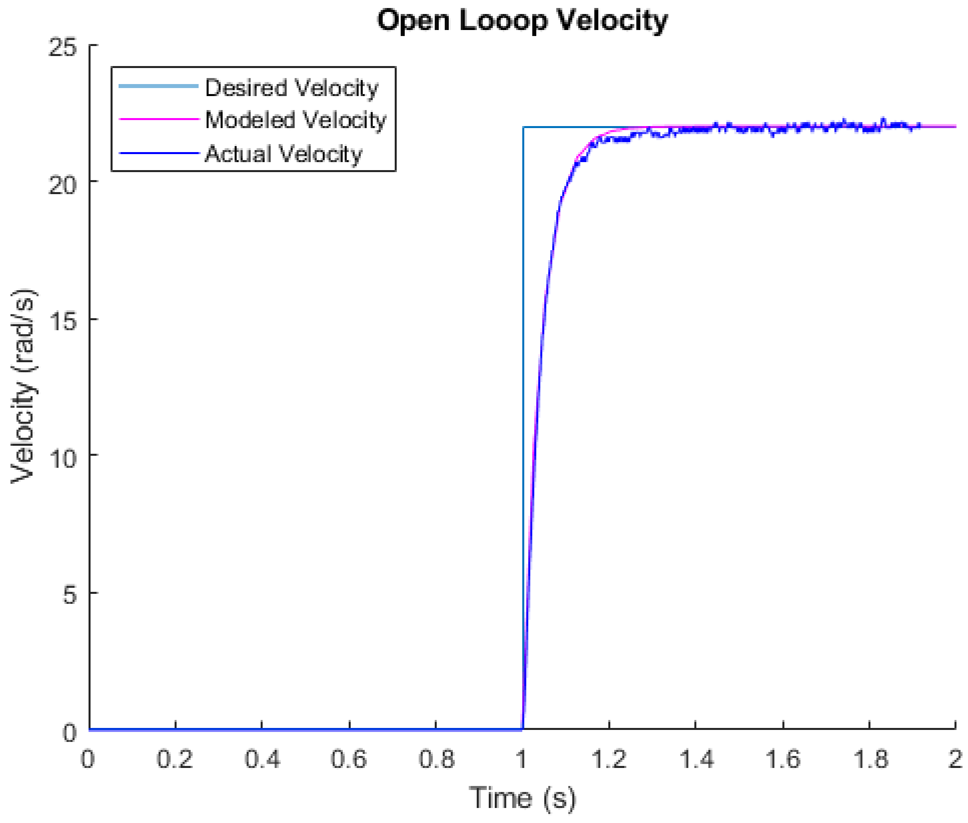
Luis Cisneros

Contents

Mini Project 4.6: Simulate and Tune the Model to Match the 'actual' Data

The controller was designed using MATLAB to guess and check sigma and K values that could be used to simplify the transfer function for the step response recorded from the motor step response data. This is done graphically by overlaying the two graphs to determine the sigma and K values that best match the recorded motor performance. NOTE: The format of the 'actual' matrix should be [0,dataColumn]

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% User variables %%%%%%%%%%%%%%%%%%%%%%%%%%%%%
sampleRate = 1; % Number of MILLISECONDS between samples

sigma = 23.5; % Tune to match 'actual' plot
K = 22; % Gain. AKA the final velocity
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% Add the time column to the 'actual' matrix (uncomment as needed)
load('actual.mat'); % Load the measured velocity values
actual(:,1) = (0 : 1 / (sampleRate * 1000) : (size(actual,1) - 1) / 1000); % Use the sampling rate to create the time column
out = sim('Mini_motorsim4_1'); % Run the simulation and make the results part of the out. object

% Plot the results
clf; figure(1); hold on;
plot(out.step * K); % Plot the step input
plot(out.newv,'m-'); % Plot the modeled step response
plot(actual(:,1),actual(:,2), 'b-'); ylabel('Velocity (rad/s)'); xlabel('Time (s)'); % Plot the actual step response
title('Open Looop Velocity'); legend({'Desired Velocity','Modeled Velocity','Actual Velocity'},'Location','northwest'); hold off;
```

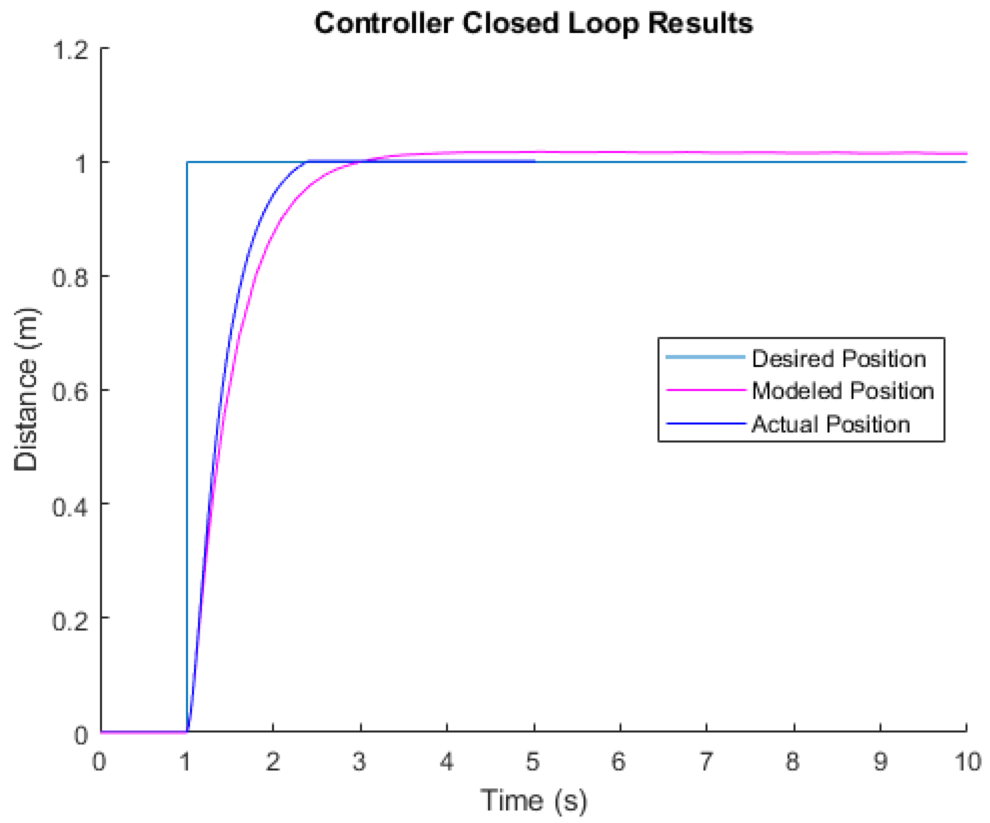


Mini Project 4.7: Design a Controller for Your Motor

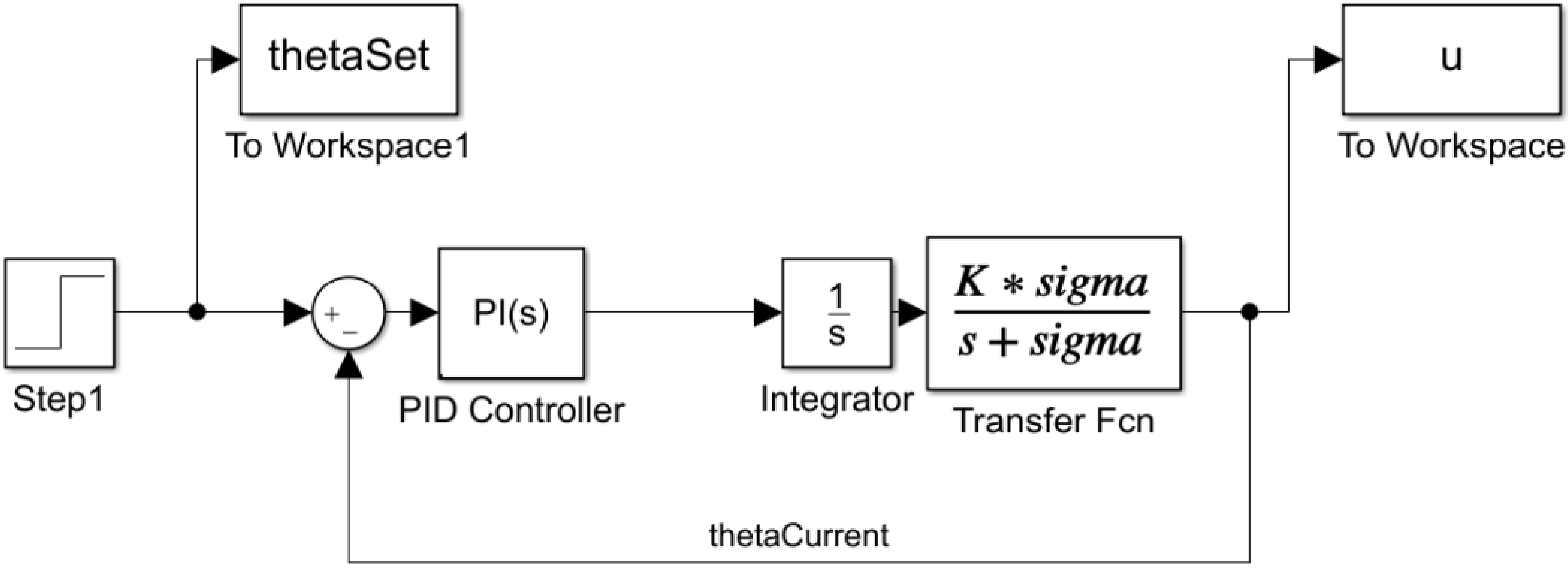
Simulink was then used to tune a PI controller to the desired specifications of a rise time of 1 second and a percent overshoot of less than or equal to 12% while having zero steady state error. The PI controller that was selected had a rise time of exactly 1 second while having a percent overshoot of 1.58% as seen in the screenshot below.

The actual and the modeled closed loop performance differed only slightly as it got closer to steady state. The actual closed loop performance recorded is slightly faster than the modeled. This is likely due to the battery being charged after the initial step response was recorded, and therefore having more power and turning the motor faster than expected.

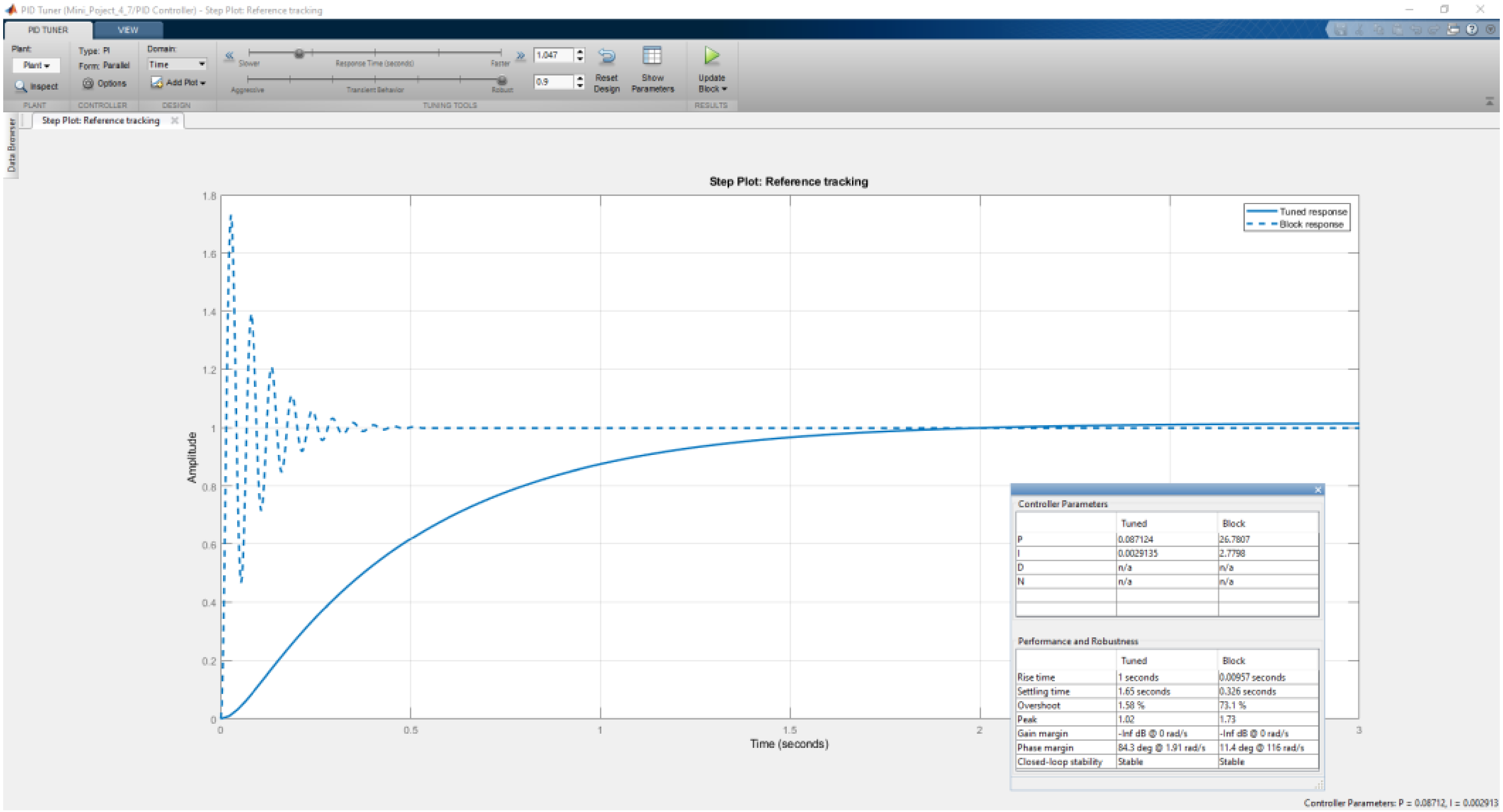
```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%% User variables %%%%%%%%%%%%%%%%%%%%%%%%%%%%%
sigma = 23.5;
K = 22;
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

load('closedLoopActual.mat'); % Load the measured closed loop position values
closedLoopActual(:,1) = closedLoopActual(:,1) / 1000; % Change the units from ms to seconds
closedLoopActual(:,1) = closedLoopActual(:,1) + 1;
closedLoopActual(:,2) = closedLoopActual(:,2)/max(closedLoopActual(:,2)); % Scale the max position to 1
out = sim('Mini_Poject_4_7'); % run the simulation

% Plot the results
clf; figure(2); hold on;
plot(out.thetaSet); % Plot the desired position
plot(out.u, 'm-'); % Plot the actual position
plot(closedLoopActual(:,1),closedLoopActual(:,2), 'b-'); ylabel('Distance (m)'); xlabel('Time (s)'); % Plot the actual step response
title('Controller Closed Loop Results'); legend({'Desired Position','Modeled Position','Actual Position'},'Location','east'); hold off;
```



Simulink Block Diagram



Simulink Tuned PI Performance



PID Tuner (Mini_Poject_4_7/PID Controller) - Step Plot: Reference tracking

Type: PI

Form: Parallel

Domain: Time

Response Time (seconds): 1.047

Transient Behavior: 0.9

Controller Parameters

	Tuned	Block
P	0.087124	26.7807
I	0.0029135	2.7798
D	n/a	n/a
N	n/a	n/a

Performance and Robustness

	Tuned	Block
Rise time	1 seconds	0.00957 seconds
Settling time	1.65 seconds	0.326 seconds
Overshoot	1.58 %	73.1 %
Peak	1.02	1.73
Gain margin	-Inf dB @ 0 rad/s	-Inf dB @ 0 rad/s
Phase margin	84.3 deg @ 1.91 rad/s	11.4 deg @ 116 rad/s
Closed-loop stability	Stable	Stable

Controller Parameters: P = 0.08712, I = 0.002913

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