Robotics Principles

5ELEN018C

Coursework

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PID Tuning

After setting up the PID controller, the controller tuned to obtain the following values.

P	1.23536773984114
I	0.685851038331636
D	-1.0302209091742
N	0.895882915429741

The response times and the transient behavior was set to these values.

Response Time	3.8408
Transient Behavior	0.6

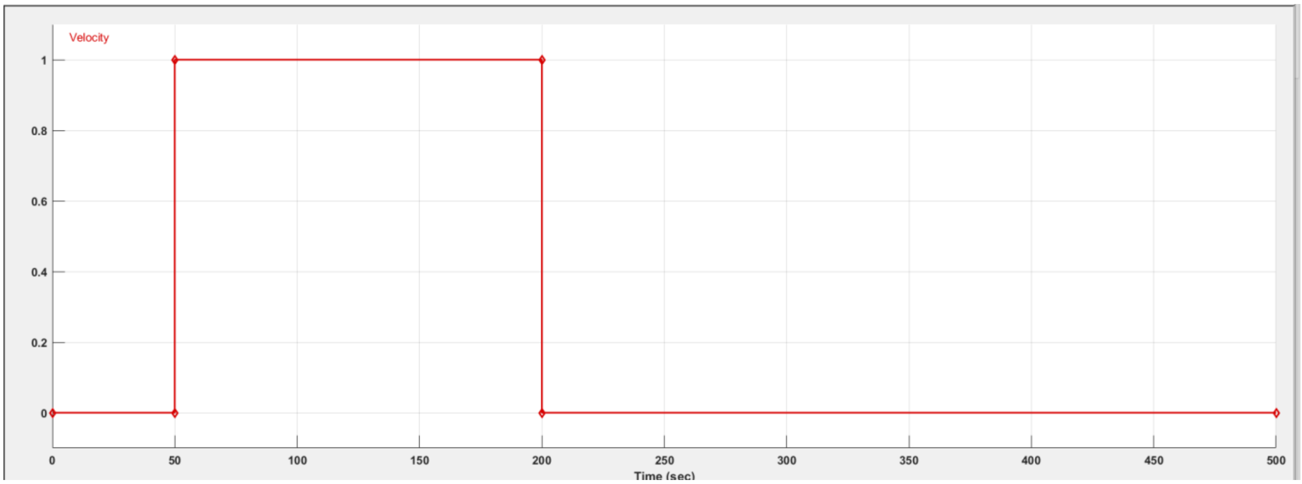
Which resulted in the following performance measurements,

Rise time	3.46 seconds
Settling time	8.48 seconds
Overshoot	16.3 %
Peak	1.16
Gain margin	-Inf dB @ 0 rad/s
Phase margin	64.5 deg @ 0.521 rad/s
Closed-loop stability	64.5 deg @ 0.521 rad/s

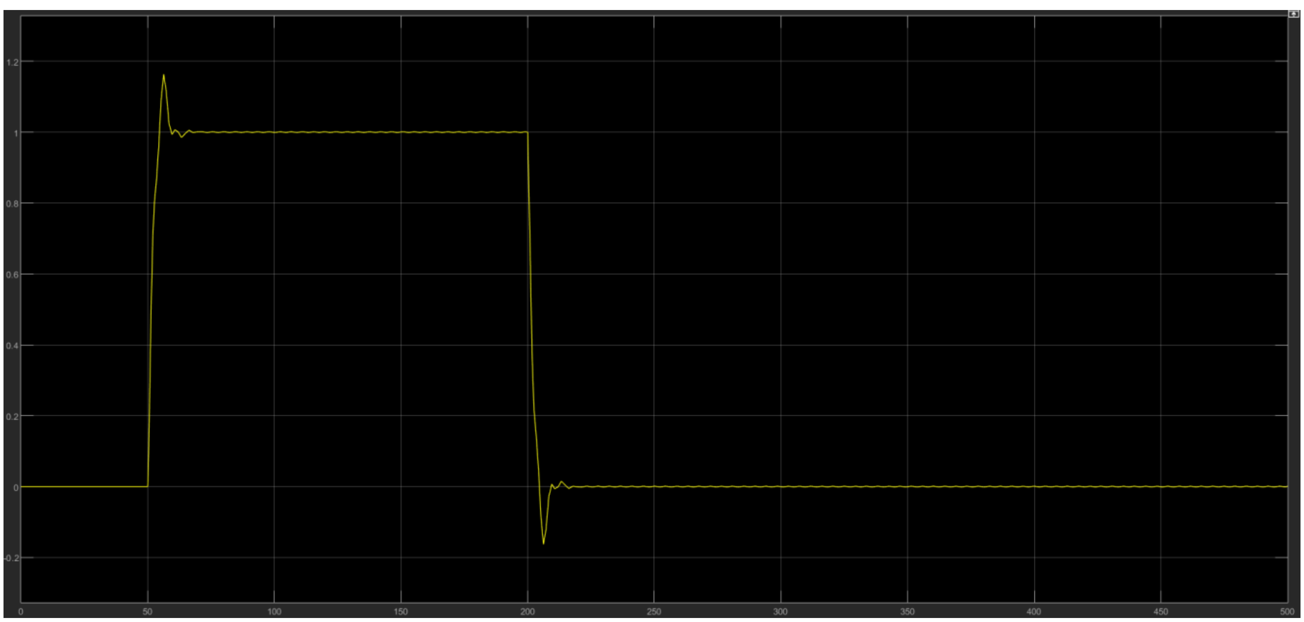
The velocity of the car determines how the car trailer system is regulated. The car begins at a speed of 0, increases to 1 after 50 seconds, and maintains this speed for 150 seconds until achieves rest. To drive the system to this behavior, a control system is needed to vary the required driving force. The overshoot of 16.3%, which results in a peak of 1.16, does not have a particularly significant effect when examine the scale of the system as there are no dangerous margins around the required speed. Settling time of the system is 8.48 seconds noticeable when the vehicle initially makes its speed to 1 and when it comes to a rest from the speed. This is also sustainable when seen in the context of the system's entire runtime. (System does not need any rapid settling times since it is not highly time sensitive.

Comparison of the reference signal given and the actual response of the system

The controller should attempt to drive the system according to the reference signal, which is a signal that represents the vehicle's velocity.

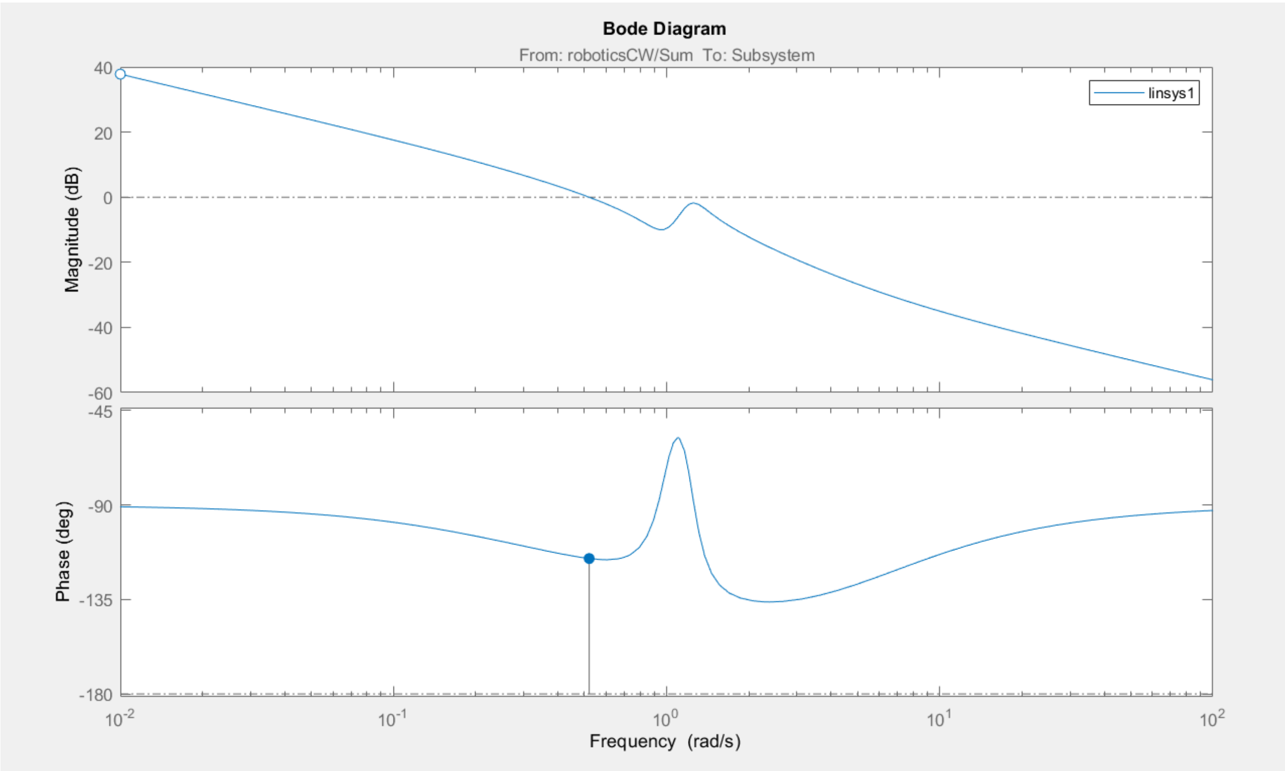


Actual response of the system for the velocity of the car after applying the tuned controller



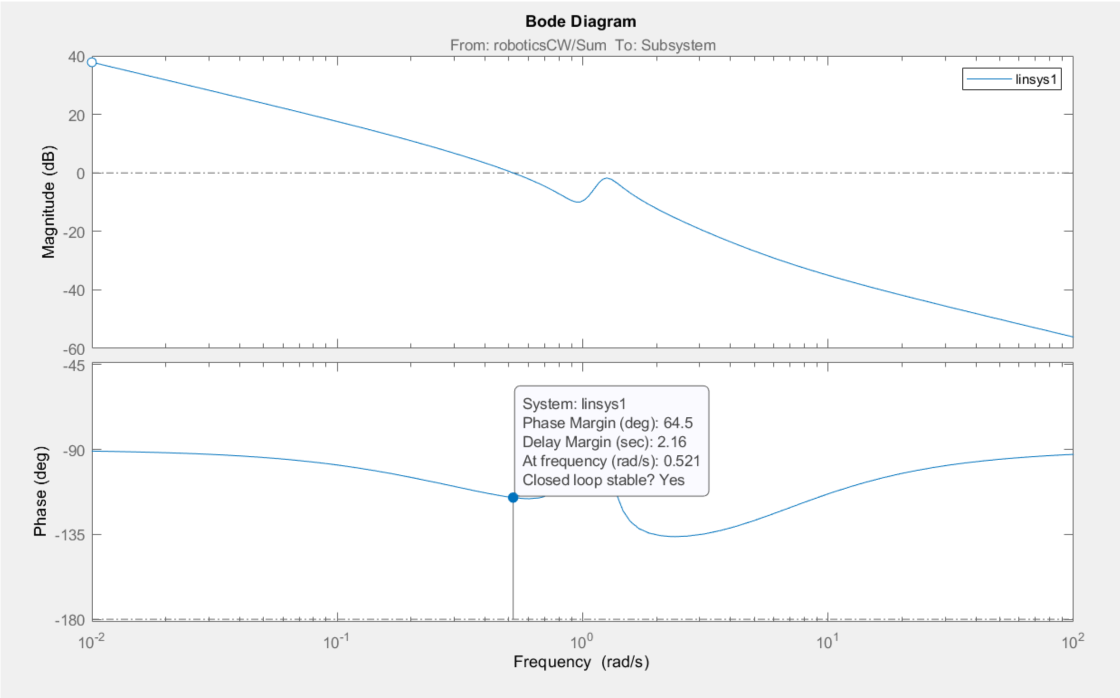
Response Diagrams

Bode Plot



In the above shown bode plot, peak response on magnitude is 37.8dB.

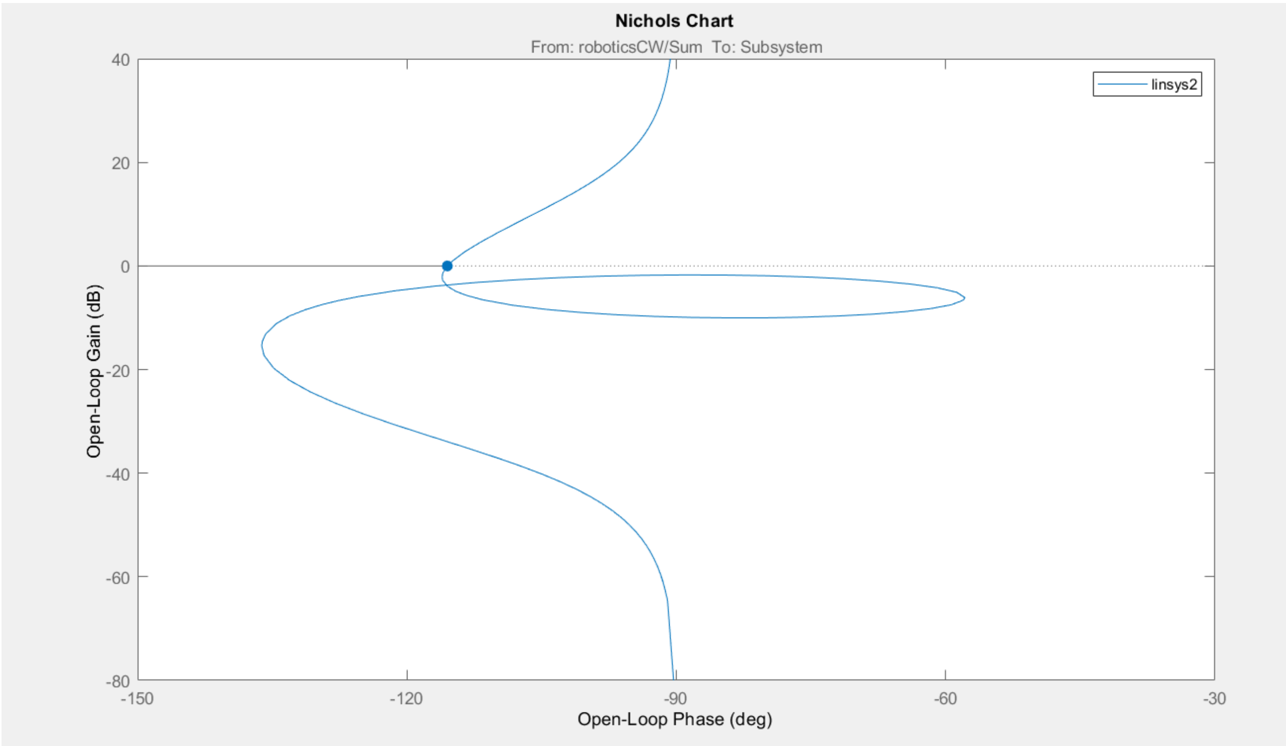
The system shown to be out of phase by -90 degrees at first, then reaching a peak phase of -58.4 degrees at a frequency of 1.09 rad/s and then going to asymptote to a -90 degree phase.



The phase margin of the phase plot that corresponds to the point where the magnitude plot crosses the y=0 line is 64.5 degrees, with a frequency of 0.521 rad/s. 64.5 degrees is a positive value greater than 45 degrees which indicates that the system is closed-loop stable.

There is no point when the phase crosses the -180 line since the phase has an asymptote. The gain margin is thus seen to be infinite.

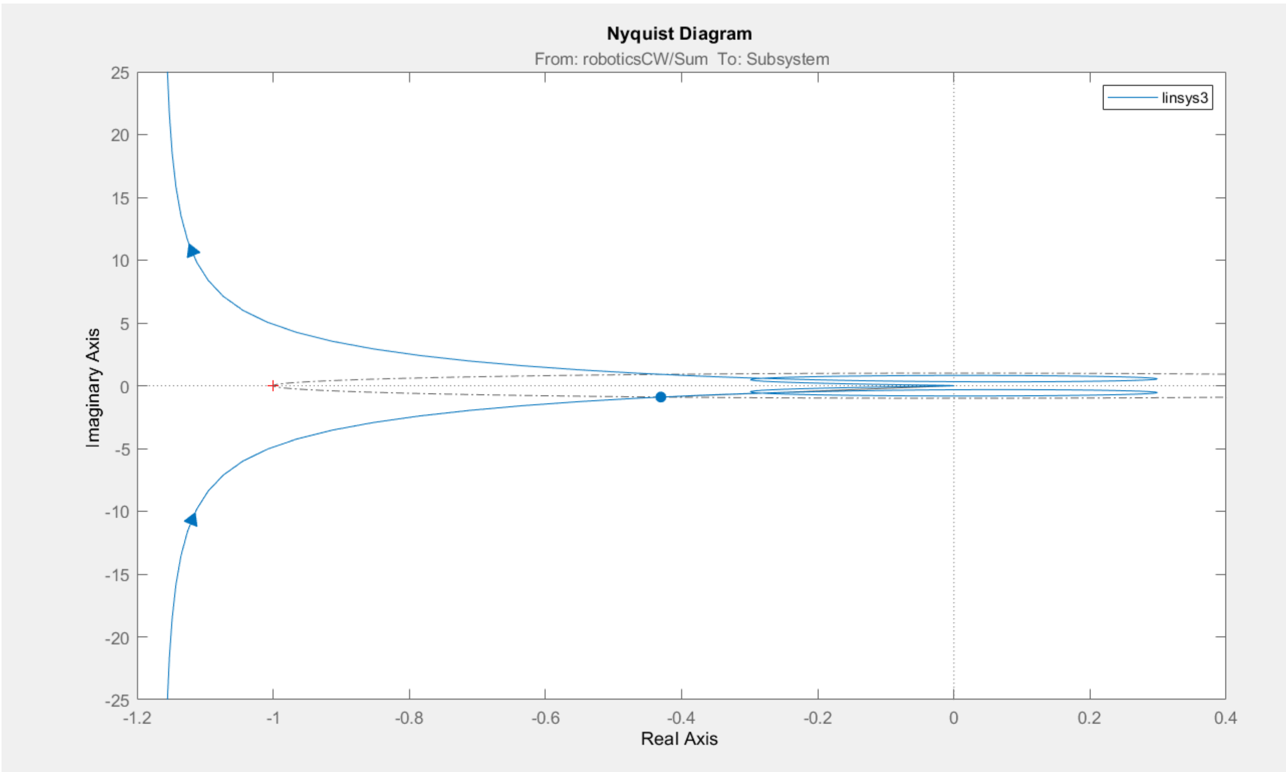
Nichols Plot



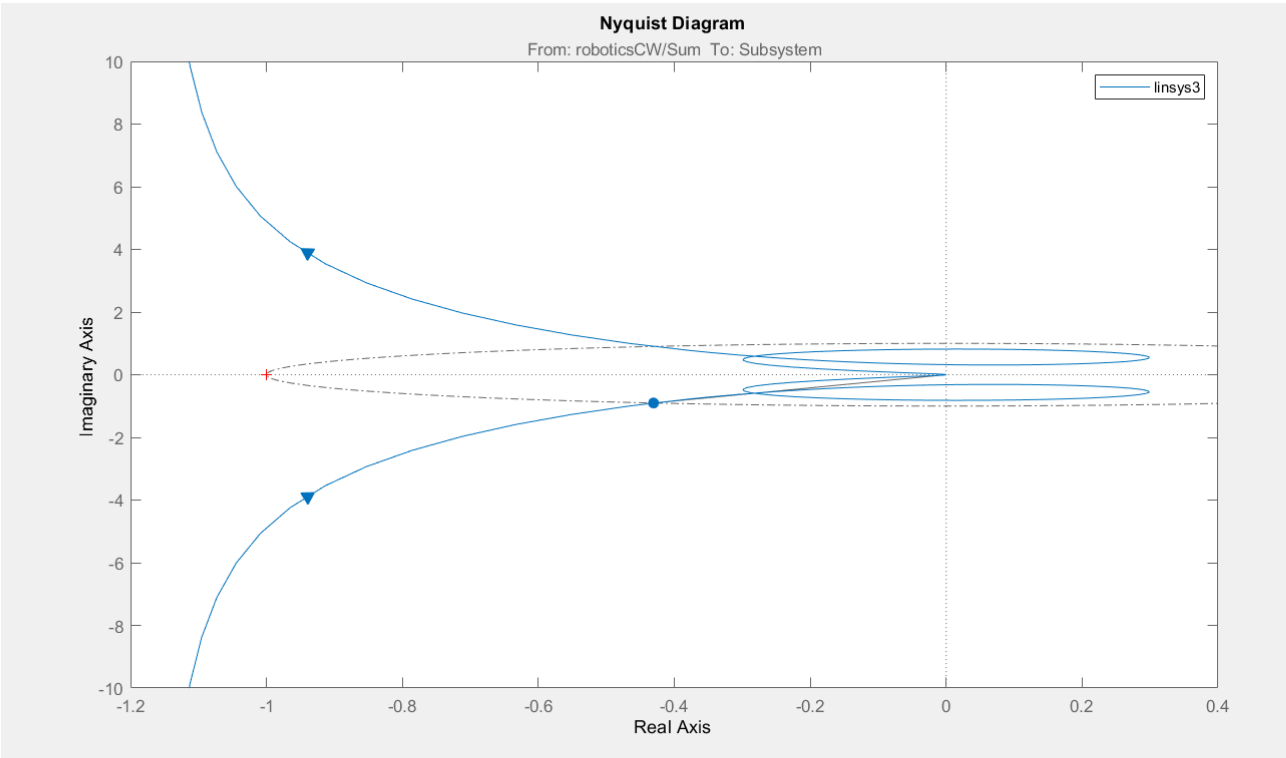
Here it can be seen that phase margin 64.5 degrees which is a positive value at the frequency 0.521 rad. Both the Open-Loop Gain and the Open Loop Phase are not negative in this configuration of the system. These traits show that the system is stable in a closed-loop.

Nyquist Plot

Nyquist Plot Full View



Nyquist Plot Zoomed on (-1,0)



In the Nyquist, it is noticeable that no loop is formed around the (-1,0) point which allows us to infer that the system is stable in a closed loop.