Objective : Linear analysis of PD controller on SISO bike model from steering rate to roll rate.

* Considering the continuous time transfer functions of the bike and the PD controller as in Figure 1, the closed-loop is stable for large enough and any value of . This is validated by simulations.
* When changing the PD to discrete time, the closed-loop is unstable for any non-zero value of . The closed-loop is stable for .

Questions :

* The model in Figure 1 does not include the dynamics of the steering motor which are included in the simulation, how does the steering motor influence the stability of the closed-loop ?
  + Removing the steering motor block in Simulink leads to a stable closed-loop with discrete time PD controller.
* What changes can be made to the controller to ensure stability of the closed-loop ?

-1

Bike

PD Controller

Figure - Block diagram of the bike with PD controller closed-loop

|  |  |  |
| --- | --- | --- |
|  | PD continuous time | PD discrete time |
| Steering motor dynamics included | Stable | Unstable |
| Steering motor dynamics excluded | Stable | Stable |

Open loop block diagram :

Bike

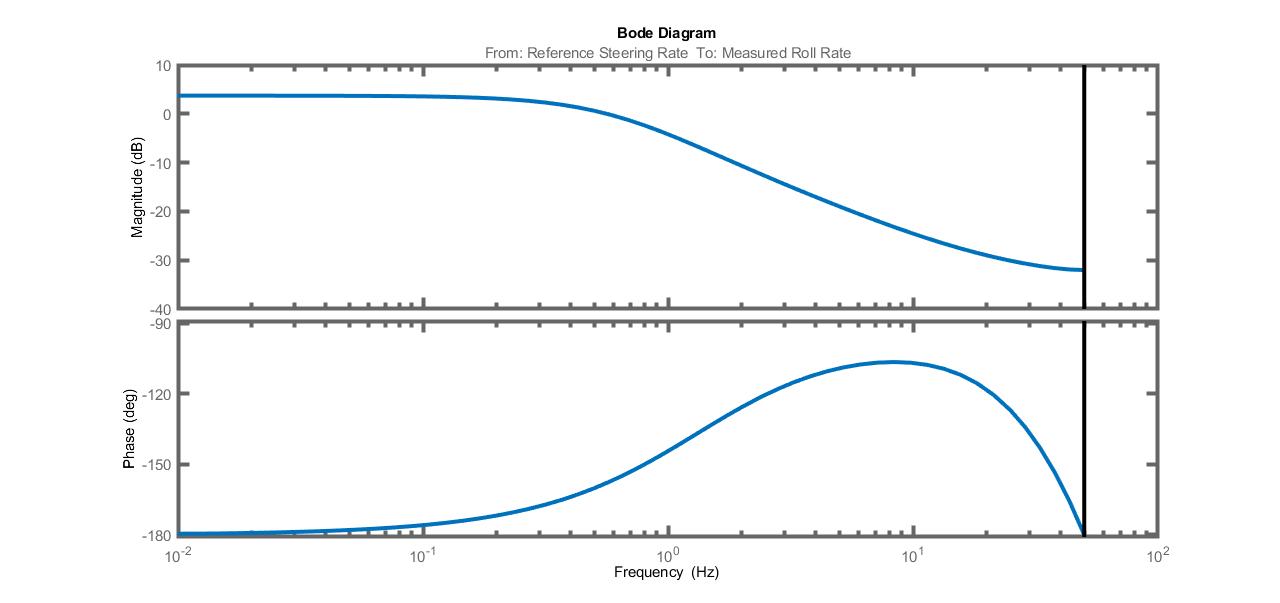
Steering motor

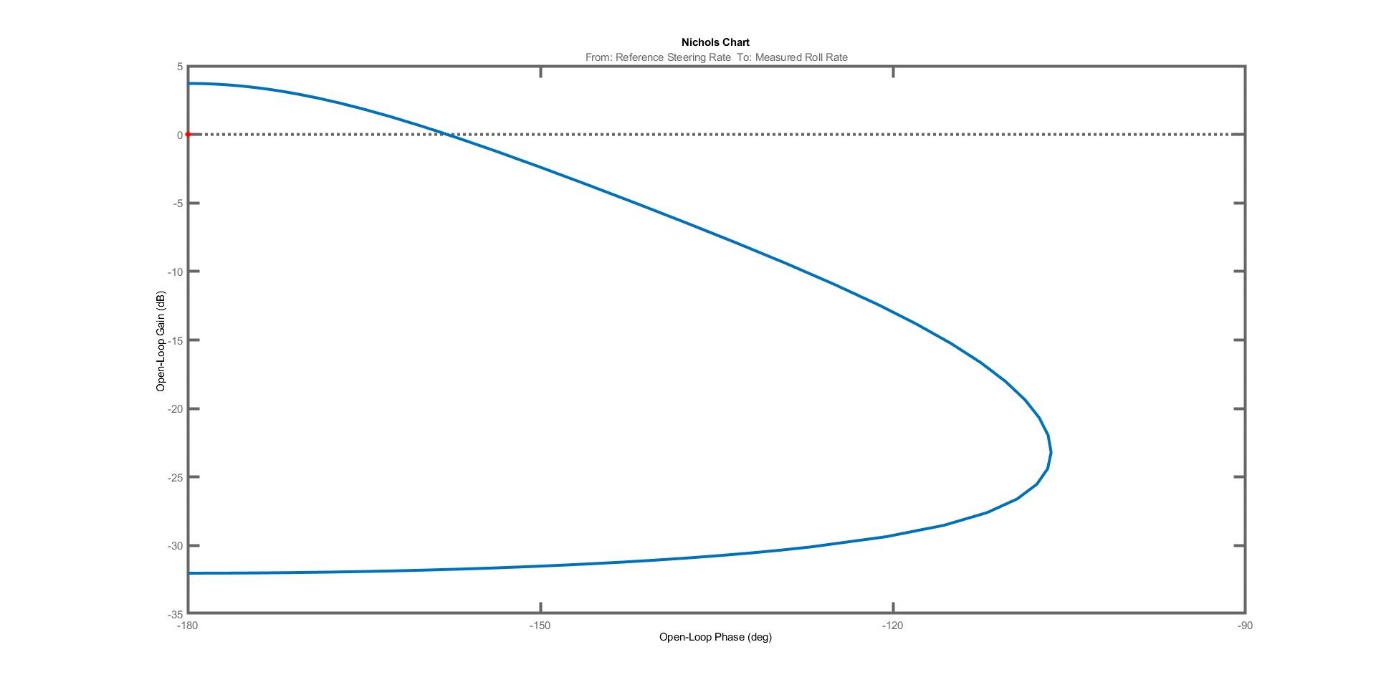
Bike model :

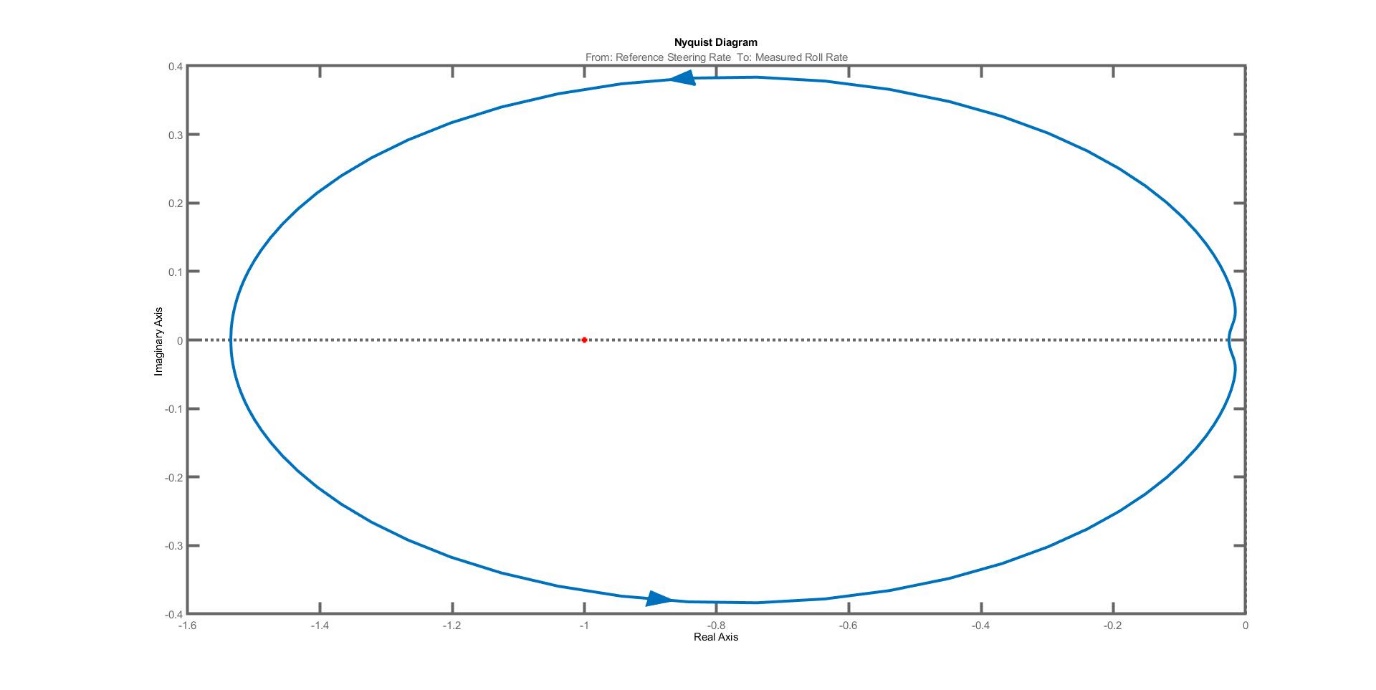
where is the inertia of the front wheel, fork and handlebar of the bike

Steering motor model :

Open loop analysis : The closed-loop with unit feedback is stable.







Closed loop block diagram :

-1

Bike

Steering Motor

PD Controller

PD controller :

Closed loop equation in Laplace domain :

The closed loop is stable iif has zeros with negative real part. For , this is true for and any positive value of .