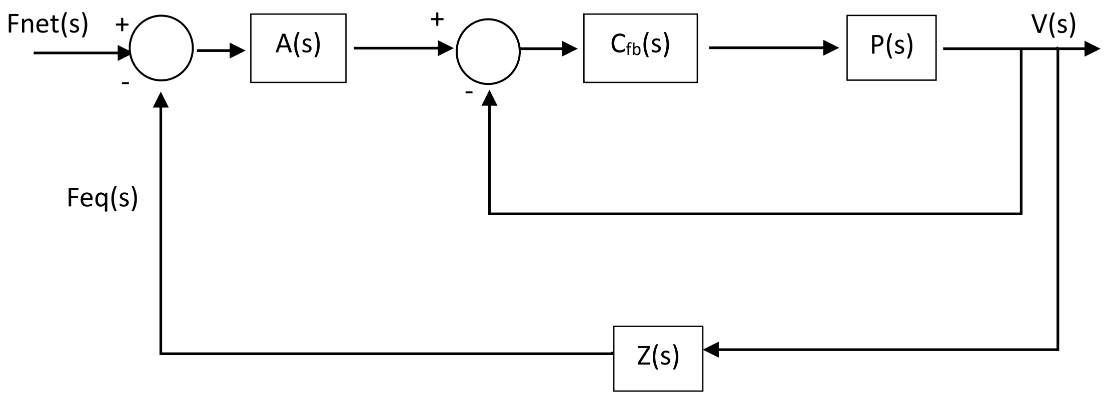
TOGAC27_CD_TransferFunctionDerivAndStability.docx

The control schemes in this document are to represent the design of a basic feedback system for velocity control. These expound further on the details found in TOGAC6_CD_ControlSystemsDesign.docx.

This document also includes the feedforward and feedforward linearization system that was used to understand how feedforward works and how gravity compensation could be considered upon improving the performance of system. It was deemed that the included feedforward and feedforward linearization system plant design would lead to highly unstable internal stability and would not be used in the actual design, although concepts for gravity compensation may be incorporated.

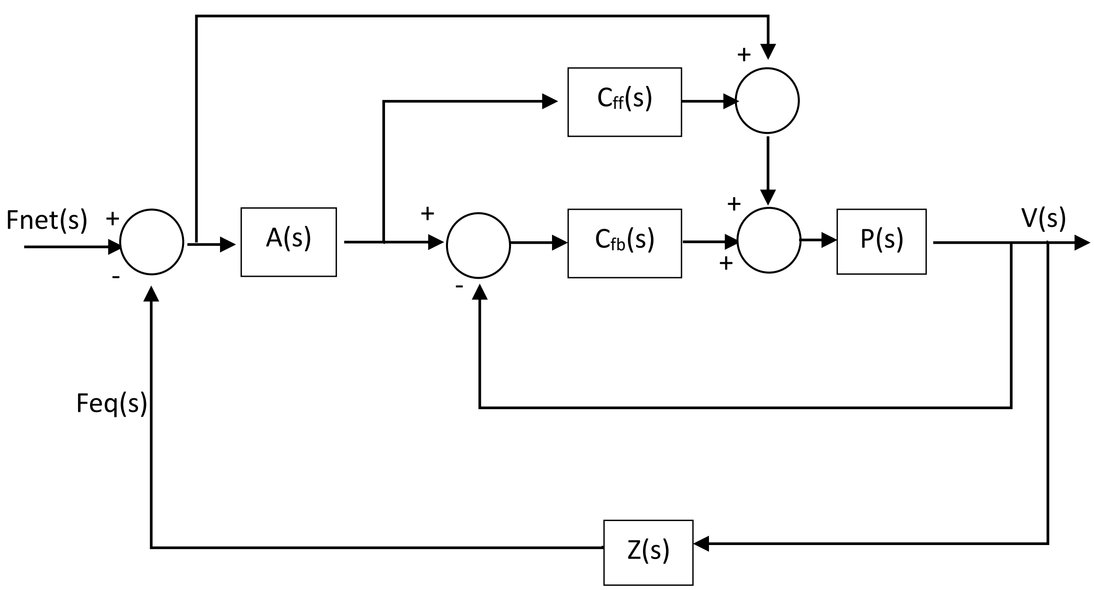
The transfer functions for each system are also included and an appendix containing relevant symbolic transfer functions is included as well.

Admittance Controller Design for Feedback only system



$$T(s) = \frac{V}{F} = \frac{AC_{fb}P}{1+C_{fb}P(AZ+1)} \qquad \text{Eq 1}$$

<u>Admittance Controller Design for Feedback, Feedforward, and Feedforward linearization system</u>



$$T(s) = \frac{V}{F} = \frac{P\left(AC_{fb}+AC_{ff}+1\right)}{PZ\left(AC_{fb}+AC_{ff}+1\right)+PC_{fb}+1} \qquad \text{Eq 2}$$

Methods for stability analysis: See check_stable.m

Aydin et al. : Closed Loop Poles of T(s) with root locus

Stienen et al. : Open Loop Phase of $\frac{F_{eq}}{F_{net}} = Y_a Zeq$

$$T(s) = \frac{F_{eq}(s)}{F_{net}(s)} = \frac{AC_{fb}PZ}{PC_{fb}+1} \quad Eq\ 3$$

$$T(s) = \frac{F_{eq}(s)}{F_{net}(s)} = \frac{(A(C_{fb}+C_{ff})+1)PZ}{PC_{fb}+1} \quad Eq\ 4$$

Admittance

$$A(s) = \frac{1}{m_{ad}s + b_{ad}}$$

Plant variations

$P_1(s) = \frac{1}{ms^2+bs+k}$ Position

$P_2(s) = \frac{s}{ms^2+bs+k}$ Position derivative -> Velocity

$P_3(s) = \frac{1}{ms+b}$ Velocity no stiffness

Impedance

$$Zeq(s) = mhs^2 + bhs + \frac{kh}{s} + \frac{ke}{s}$$