PID Position Control of a Hydraulic Actuator with Noise Filter

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This file produces root locus diagram and step responses for
PID position control of a hydraulic actuator with a first order noise
filter in the feedback path.

Clear Variables and start pause feature

clear p a b f t Kd poles numP denP sysOL sysCL BW DC_gain
clear titlestringRL titlestring performanceCharacteristics
disp('PID Position Control of a Hydraulic Actuator with Noise Filter')

% turn on pause feature
pause on;

PID Position Control of a Hydraulic Actuator with Noise Filter

Define parameters

p = 2.0; % real pole of actuator
a = 4; % Kp/Kd - ratio of proportional to derivative gains
b = 3; % Ki/Kd - ratio of integral to derivative gains
f = 30; % filter frequency (r/s)
t = [0:0.01:3.0]; % time interval

Plot the root locus diagram

% define the transfer funtion of the PID compensated, open-loop system
numP = f*[1,a,b]; denP = conv(conv([1,0,0],[1,p]),[1,f]); sysOL = tf(numP,denP);

% plot the root locus diagram of the system in figure window #1
figure(1); clf; hold on;
rlocus(sysOL); grid on;
titlestringRL = ['Root Locus Diagram for Kd (p = ',num2str(p),', Kp/Kd = ',num2str(a),', Ki/Kd = ',num2str(b),', f = ',num2str(f),'')];
title(titlestringRL);
Find a suitable "K" for the closed loop system

```matlab
% pause so user can zoom into area of interest
pause;
% call rlocfind to choose location of poles and find derivative gain (Kd)
[Kd,poles] = rlocfind(sysOL);
% display the derivative gain (Kd) and the associated closed-loop poles
disp('Derivative Gain:'); disp(Kd);
disp(['Poles Associated with this Gain:']); disp(poles);

Selected point in the graphics window
selected_point =
    -13.3645655877342 + 2.67219917012448i

Derivative Gain:
    8.99498059190506

Poles Associated with this Gain:
    -13.4311526094723 + 2.66948460505176i
    -13.4311526094723 - 2.66948460505176i
    -4.07944097078072
    -1.05825381027471
```
Plot the step response of the closed loop system with the selected "K"

```matlab
% define the transfer function of the PID compensated, closed-loop system
sysCL = feedback(Kd*sysOL,1,-1);

% plot the closed-loop step response over the specified time interval in figure window #2
figure(2); clf; hold on;
step(sysCL,t); grid on;
ylabel('Position Change (ft)');
titlestring = ['Step Response of Actuator with PID Control.', ...
              '(Kd = ', num2str(Kd), ', p = ',num2str(p), ', Kp/Kd = ', ...
              num2str(a), ', Ki/Kd = ',num2str(b), ', f = ',num2str(f),')'];
title(titlestring);

% pause to allow user to annotate the plot
pause;
```
Calculate and display the performance characteristics (performanceCharacteristics)

```matlab
% calculate the performance characteristics
performanceCharacteristics = stepinfo(sysCL);

% display the performance characteristics in Command window
disp('Performance Data for the Compensated System');
disp('==============================================');
disp('Rise Time (sec) ='); disp(performanceCharacteristics.RiseTime);
disp('Settling Time (sec) ='); disp(performanceCharacteristics.SettlingTime);
disp('Percent Overshoot ='); disp(performanceCharacteristics.Overshoot);
disp('Peak Value ='); disp(performanceCharacteristics.Peak);
disp('Peak Time (sec) ='); disp(performanceCharacteristics.PeakTime);
```

Performance Data for the Compensated System
==============================================
Rise Time (sec) =
0.136111835658802

Settling Time (sec) =
1.26615896235971

Percent Overshoot =
15.7467282693216

Peak Value =
1.15746728269322

Peak Time (sec) =
Plot the Bode diagram of the closed loop system with chosen $K$.

```matlab
% plot the bode diagram of the PID compensated, closed-loop system in figure window
figure(3); clf;
bode(sysCL); grid on
titlestring = ['Bode Diagram of Closed Loop Hydraulic Actuator and Filter with ' ...
    ' (Kd = ', num2str(Kd), ', p = ',num2str(p), ', Kp/Kd = ', ...
    num2str(a), ', Ki/Kd = ',num2str(b),'')];
title(titlestring);

% pause to allow user to annotate the plot
pause;

% calculate the closed-loop system bandwidth (BW) and low frequency gain (DC_gain) and display them in the Command window
BW = bandwidth(sysCL); DC_gain = 20*log10(dcgain(sysCL));
disp('DC Gain and Bandwidth of the Compensated, Closed-loop System');
disp('============================================================');
disp('DC Gain (dB) ='); disp(DC_gain);
disp('Bandwidth (rad/s) ='); disp(BW);

% turn off pause feature
pause off;
```

**DC Gain and Bandwidth of the Compensated, Closed-loop System**

**DC Gain (dB) =**

$0$

**Bandwidth (rad/s) =**

$13.9233691873697$
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