PD Position Control of a Spring-Mass-Damper

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This file produces root locus diagram and step responses for PD position control of a spring-mass-damper system.

It also plots a Bode diagram of the closed loop system.

Clear Variables and turn on pause feature

```matlab
clear m c kspring a Kd poles numP denP sysOL sysCL performanceCharacteristics
clear titlestringRL titlestring
disp ( 'PD Position Control of a Spring-Mass-Damper' );
% turn on pause feature
pause on;
```

Define parameters

```matlab
m = 1.0; % mass in slugs
c = 8.8; % damping coefficient in lb-s/ft
kspring = 40.0; % spring stiffness in lb/ft
a = 10.0; % zero for PD controller = Kp/Kd
```

Define the open-loop transfer function and plot the root locus diagram

```matlab
% define the open-loop transfer function (sysOL)
numP = [1,a]; denP = [m,c,kspring]; sysOL = tf(numP,denP);
% plot the root locus diagram in figure window #1
```
Find a suitable derivative gain "Kd" for the closed loop system

% pause to allow user to zoom into areas of interest
pause;

% call rlocfind to allow user to pick the pole locations
[Kd,poles] = rlocfind(sysOL);

% display the derivative gain and associated poles in Command Window
disp('Derivative Gain:'); disp(Kd);
disp('Poles Associated with this Gain:'); disp(poles);

Select a point in the graphics window

selected_point =
-16.3628620102215 + 3.30290456431536i

Derivative Gain:
24.0006323981646
Define the closed-loop transfer function with the selected gain "Kd" and plot the step response

```matlab
% define the closed-loop transfer function (sysCL) with selected gain (Kd) and negative unity feedback
sysCL = feedback(Kd*sysOL,1,-1);

% plot the closed loop step response in figure #2
figure(2); clf; hold on;
step(sysCL); grid on;
ylabel( 'Position Change (ft)' );
titlestring = ['Step Response of SMD with PD Control. (Kd = ' ,num2str(Kd), '), (Kp/Kd = ' ,num2str(a), ')'];
title(titlestring);

% pause to allow user to annotate the plot
pause;
```
Calculate and display the closed-loop performance characteristics to Command Window

% calculate performance characteristics; stored in structure PerChar
performanceCharacteristics = stepinfo(sysCL);

% display results to 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) = 0.0575692686326021
Settling Time (sec) = 0.288985113015068
Percent Overshoot = 6.78437135426346
Peak Value = 0.915298056950588

Peak Time (sec) = 0.143938471782287

Plot the Bode diagram of the closed loop system and display characteristics in Command Window

```matlab
% plot the Bode diagram of the closed-loop system in figure #3
figure(3); clf;
bode(sysCL); grid on;
titlestring = ['Bode Diagram of Closed Loop SMD with PD Control. (Kd = ', num2str(Kd), '), (Kp/Kd = ',num2str(a),'')];
title(titlestring);

% pause to allow user to annotate the plot
pause;

% calculate the bandwidth and DC gain of the closed-loop system
BW = bandwidth(sysCL); DC_gain = 20*log10(dcgain(sysCL));

% display the frequency response characteristics of the closed loop system
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 pause feature off
pause off;
```

DC Gain and Bandwidth of the Compensated, Closed-loop System
============================================================
DC Gain (dB) = -1.33890309733686
Bandwidth (rad/s) = 33.4342094533137
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