**PID Position Control of a Hydraulic Actuator**

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This file produces root locus diagram and step responses for PID position control of a hydraulic actuator.

### Clear Variables and start the pause feature

```matlab
clear p a b Kd poles numP denP K sysOL sysCL time tmax numint denint x y
```

```matlab
clear titlestringRL titlestring performanceCharacteristics
disp('PID Position Control of a Hydraulic Actuator');
```

```matlab
% turn on pause feature
pause on;
```

### Define parameters

```matlab
p = 2.0; % real pole of actuator
a = 4; % Kp/Kd - ratio of the proportional to derivative gains
b = 3; % Ki/Kd - ratio of the integral to derivative gains
```

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

```matlab
numP = [1,a,b]; denP = conv([1,0,0],[1,p]); sysOL = tf(numP,denP);
```

```matlab
figure(1); clf; hold on;
```

```matlab
rlocus(sysOL); grid on;
```

```matlab
```

```matlab
```

```matlab
titlestringRL = ['Root Locus Diagram for Kd (p = ',num2str(p),'...',
' Kp/Kd = ',num2str(a),' ', Ki/Kd = ',num2str(b),'')];
title(titlestringRL);
```
Find a suitable proportional 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 =

-4.24531516183986 + 0.00518672199170167i

Derivative Gain:
10.0128685215969

Poles Associated with this Gain:
-6.71359369491002
-4.24534490528618
Plot the step response of the closed loop system with selected "Kd"

% 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 on the specified time interval in figure #2
figure(2); clf; hold on;
tmax = 2; time = [0:0.01:tmax];
step(sysCL,time); 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), ')'];
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: performanceCharacteristics
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) = 0.155080842096634
Settling Time (sec) = 1.25729673821419
Percent Overshoot = 10.3849715474096
Peak Value = 1.1038497154741

Peak Time (sec) = 0.4219447106299

**Plot the ramp response of the closed loop system with selected "Kd"**

```matlab
% define the transfer function for a step input "1/s" and place it in series with the closed loop transfer function (sysCL)
numint = [1]; denint = [1,0]; sysint = tf(numint,denint);
sysCL02 = series(sysint,sysCL);

% plot the closed loop ramp response in figure #3
% ...the step function includes another "1/s" to sysCL02 making it a ramp response
% ...a unit ramp (y=t) is plotted on the same graph for comparison purposes
figure(3); clf; hold on;
x=[0,tmax]; y=x; plot(x,y, 'k:' )
step(sysCL02,time); grid on;
ylabel( 'Position Change (ft)' );

titlestring = ['Ramp Response of Actuator with PID Control.' , ...
    ' (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;

% turn pause feature off
pause off;
```
Ramp Response of Actuator with PID Control: $K_i = 10.0129$, $p = 2$, $K_p \Delta K_i = 4$, $I_d(\Delta K_i) = 3$.

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