Helicopter Tuning Results Document

Helicopter Tuning Results Document:

Publication date 22-Oct-2018 09:37:44

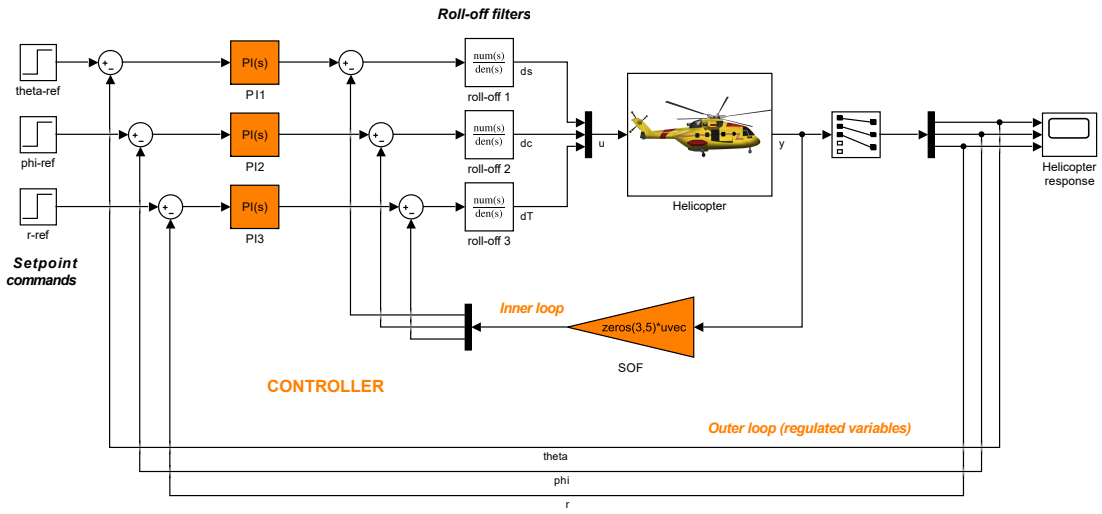
Abstract

Helicopter tuning example

Table of Contents

Chapter 1. Helicopter Control System Model

The following model contains the Helicopter Control system and plant model used for tuning the gains. This is a continuous time model that will be linearized as part of the tuning process.



Chapter 2. Code: Heli_tuning_script

MATLAB Tuning Code. The following code uses Simulink Control Design to tune the inner and outer loop gains for the helicopter control system. The inner loop control is a mulitvariable control loop and the outer loop consists of three PI controllers, one for each axis.

```
% Helicopter tuning example

% Copyright 2016 The MathWorks, Inc.

% first, test for a Simulink Control Design, Control System Toolbox
 and
% Robust Control Toolbox licenses
if license('test','simulink_control_design')&&...

 license('test','control_toolbox')&&license('test','robust_toolbox')

    % bring command window to the front
    commandwindow;

    ST0 = slTuner('rct_helico_Sdomain',{'PI1','PI2','PI3','SOF'});

    addPoint(ST0,{'theta-ref','phi-ref','r-ref'});   % setpoint
 commands
    addPoint(ST0,{'theta','phi','r'});               % corresponding
 outputs
    addPoint(ST0,{'u','y'});

    % Less than 20% mismatch with reference model 1/(s+1)
    TrackReq = TuningGoal.StepTracking({'theta-ref','phi-ref','r-
ref'},{'theta','phi','r'},1);
    TrackReq.RelGap = 0.2;

    % Gain and phase margins at plant inputs and outputs
    MarginReq1 = TuningGoal.Margins('u',5,40);
    MarginReq2 = TuningGoal.Margins('y',5,40);

    % Limit on fast dynamics
    MaxFrequency = 25;
    PoleReq = TuningGoal.Poles(0,0,MaxFrequency);

    AllReqs = [TrackReq,MarginReq1,MarginReq2,PoleReq];
    [ST1,fSoft,~,Info] = systune(ST0,AllReqs);

    T1 = getIOTransfer(ST1,{'theta-ref','phi-ref','r-ref'},
{'theta','phi','r'});
    step(T1,5);

    figure('Position',[100,100,900,474]);
    viewSpec(AllReqs,ST1,Info);

    showTunable(ST1);
```

```
    % Clean up
    bdclose('all');
    clearvars;

else % open the pre-existing report and post a warning
    open('Heli-Tuning-Report.pdf');
    warndlg(['There is a license missing for Simulink Control Design
 '...
        'or Control System Toolbox or Robust Control Toolbox, a ' ...
        'pre-existing tuning report has been opened'],...
        'Missing Product License');
end
```

Chapter 3. Command Window Output

Gain Results From Tuning Script. When Heli_tuning_script.m is run in the workspace, the following results are displayed to the command window for the three outer loop PI controls and inner loop matrix gains:

```
Final: Soft = 1.11, Hard = -Inf, Iterations = 137

Block 1: <a href="matlab:hilite_system('rct_helico_Sdomain/
PI1','find');pause(1);hilite_system('rct_helico_Sdomain/
PI1','none');">rct_helico_Sdomain/PI1</a> =

             1
  Kp + Ki * ---
             s

  with Kp = 1.13, Ki = 2.25

Name: PI1
Continuous-time PI controller in parallel form.

-----------------------------------

Block 2: <a href="matlab:hilite_system('rct_helico_Sdomain/
PI2','find');pause(1);hilite_system('rct_helico_Sdomain/
PI2','none');">rct_helico_Sdomain/PI2</a> =

             1
  Kp + Ki * ---
             s

  with Kp = -0.086, Ki = -1.19

Name: PI2
Continuous-time PI controller in parallel form.

-----------------------------------

Block 3: <a href="matlab:hilite_system('rct_helico_Sdomain/
PI3','find');pause(1);hilite_system('rct_helico_Sdomain/
PI3','none');">rct_helico_Sdomain/PI3</a> =

             1
  Kp + Ki * ---
             s

  with Kp = 0.133, Ki = -2.33

Name: PI3
Continuous-time PI controller in parallel form.

-----------------------------------
```

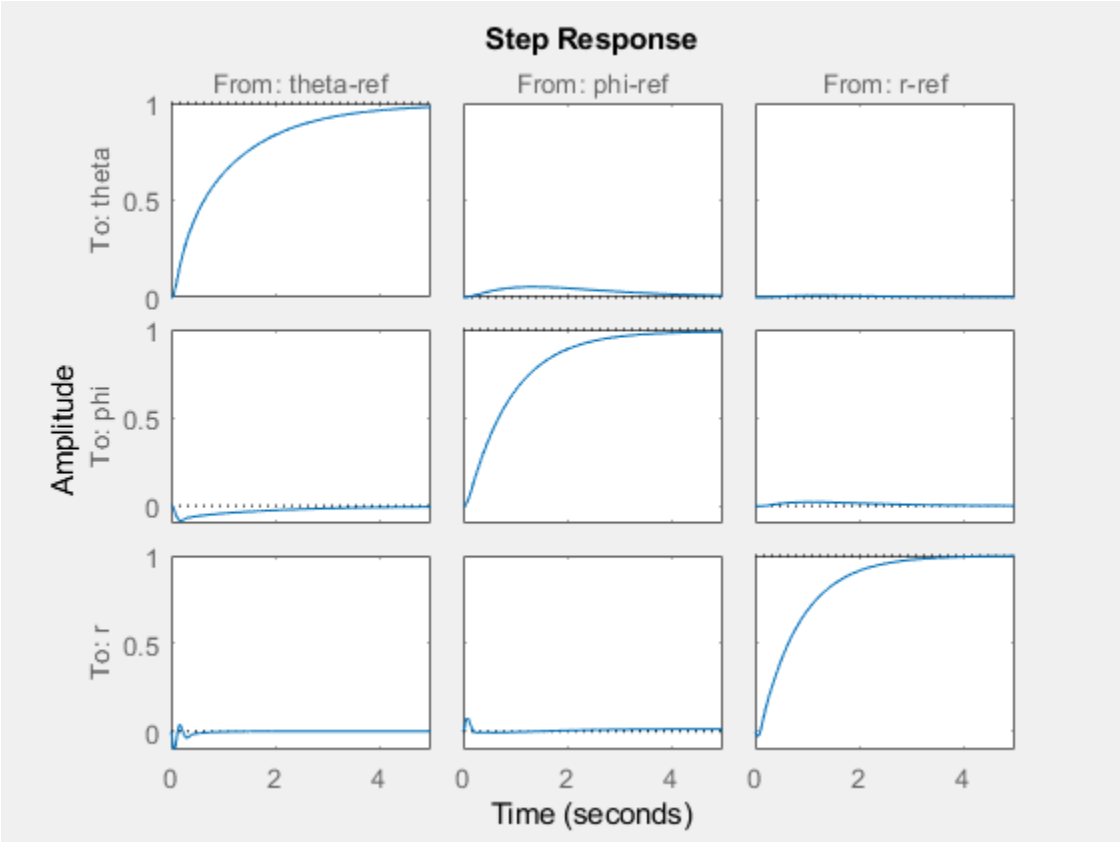
```
Block 4: <a href="matlab:hilite_system('rct_helico_Sdomain/
SOF','find');pause(1);hilite_system('rct_helico_Sdomain/
SOF','none');">rct_helico_Sdomain/SOF</a> =

  D =
              u1         u2         u3         u4         u5
   y1      2.395    -0.3609  -0.002145     0.8087    -0.0205
   y2    -0.1427     -1.115    0.04573   -0.04318    -0.1007
   y3   -0.02792   -0.02229     -2.025   -0.06152    0.03151

Name: SOF
Static gain.
```

Chapter 4. Results

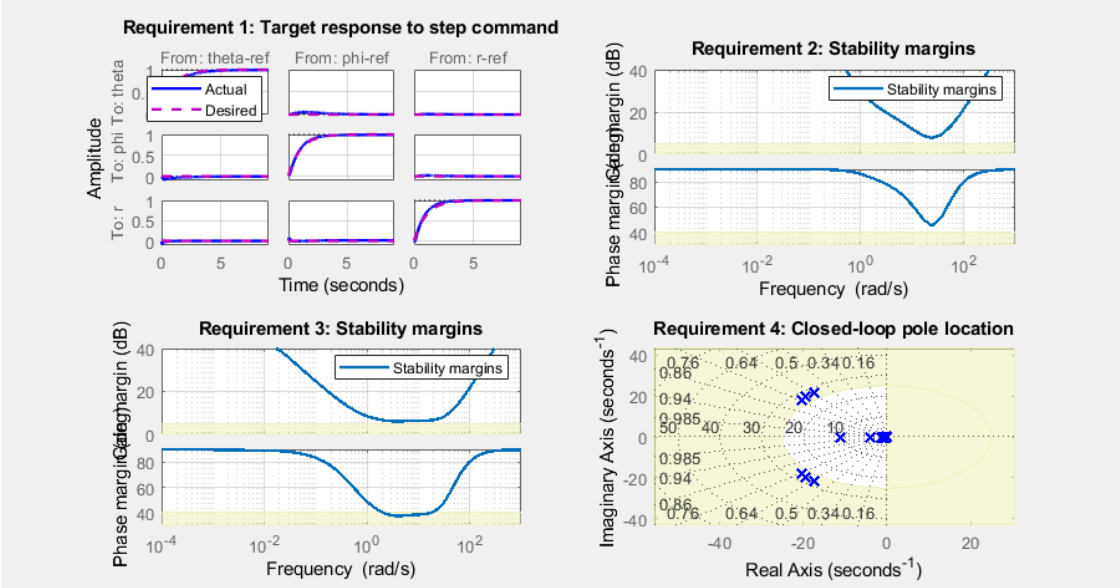
Table of Contents

Control System Responses and Stability Margins. Two figures are provided here, one that shows the step responses, and the other that shows the target responses, stability margins and closed loop pole locations. These responses are based on the slected set of gains. Running Heli_tuning_script.m creates 2 figure(s). A snapshot of each is displayed below.

4.1. Figure



4.2. Figure


Requirement 1: Target response to step command
From: theta-ref
From: phi-ref
From: r-ref
Actual
Desired
Amplitude
To: theta
To: phi
To: r
Time (seconds)
Requirement 2: Stability margins
Stability margins
Phase margin (deg)
Gain margin (dB)
Frequency (rad/s)
Requirement 3: Stability margins
Stability margins
Phase margin (deg)
Gain margin (dB)
Frequency (rad/s)
Requirement 4: Closed-loop pole location
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})