

# Helicopter Tuning Results Document

## Helicopter Tuning Results Document:

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### Abstract

Helicopter tuning example

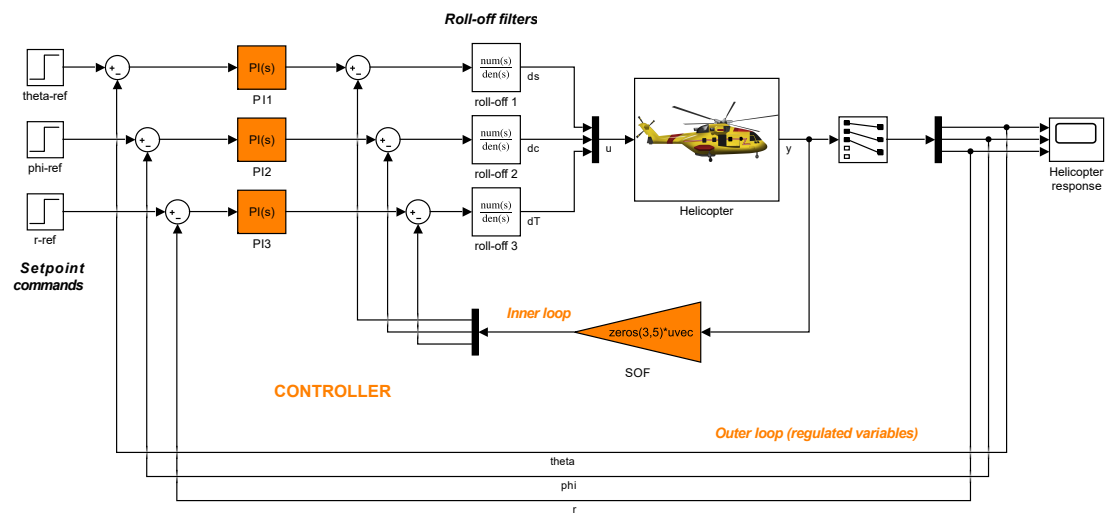
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# Chapter 1. Helicopter Control System Model

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.



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# 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 multivariable control loop and the outer loop consists of three PI controllers, one for each axis.

```
% Helicopter tuning example

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% 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]);
    viewGoal(AllReqs,ST1);

    showTunable(ST1);
```

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

else % open the pre-existing report and post a warning
    prj = simulinkproject;
    prjRoot = prj.RootFolder;

    open(fullfile(prjRoot, 'ARP_03_SystemArchitecture', 'validation', '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 = 124

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> =`

$$K_p + K_i * \frac{1}{s}$$

with  $K_p = 1.1$ ,  $K_i = 2.2$

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> =`

$$K_p + K_i * \frac{1}{s}$$

with  $K_p = -0.0928$ ,  $K_i = -1.21$

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> =`

$$K_p + K_i * \frac{1}{s}$$

with  $K_p = 0.131$ ,  $K_i = -2.3$

Name: PI3

Continuous-time PI controller in parallel form.

-----

Block 4: [>rct\\_helico\\_Sdomain/SOF</a> =](matlab:hilite_system('rct_helico_Sdomain/SOF','find');pause(1);hilite_system('rct_helico_Sdomain/SOF','none');)

D =

	u1	u2	u3	u4	u5
y1	2.353	-0.3562	-0.001917	0.8109	-0.02076
y2	-0.1557	-1.13	0.0417	-0.04584	-0.1031
y3	-0.02788	-0.01228	-2.011	-0.03679	0.02103

Name: SOF

Static gain.



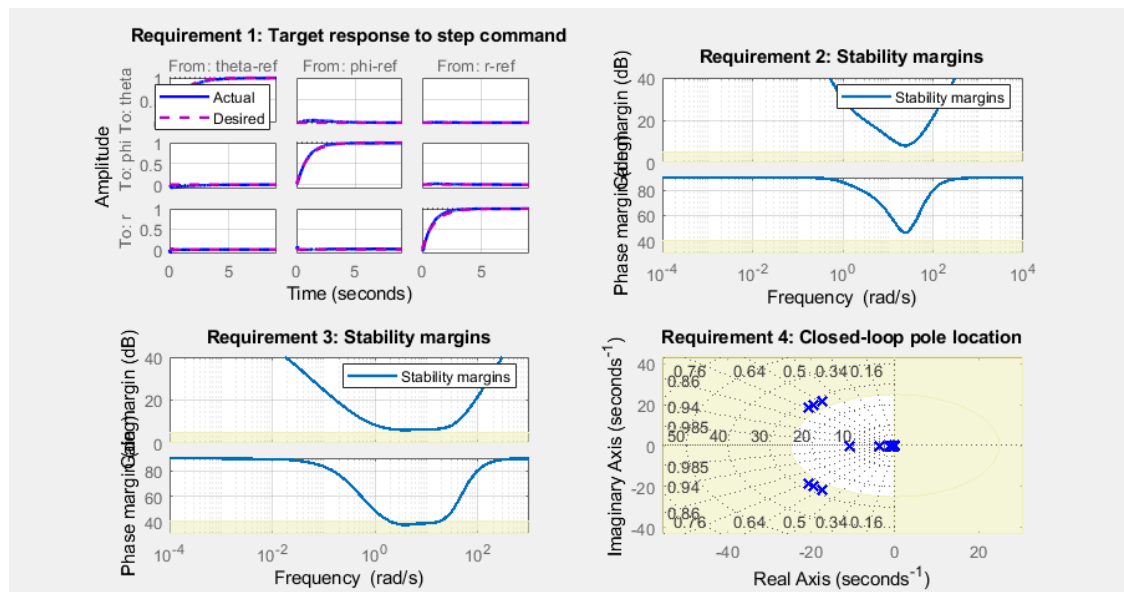
# Chapter 4. Results

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**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 selected 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

