

CONTROL METHODS

Method#02 - PID control: Tuning PID controller of the LTI, SISO system

Let's consider the following UAV stabilization system

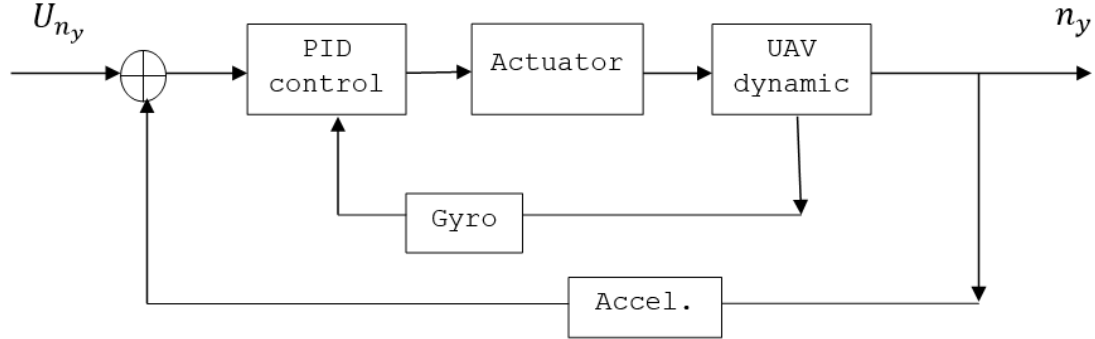


Fig.2.01 - Functional block-diagram of the UAV stabilization system

Assumptions

Measurement noise & errors of the Gyro and Accelerometer aren't taking into account in the model: $W_{gyro}(s)=1$, $W_{accel}(s)=1$.

...

PID controller

$$\delta(t) = K_p e(t) + K_D \dot{e}(t) + K_I \int_0^t e(t) dt, \quad (2.01)$$

Actuator

$$W_{act} = \frac{1}{T_{act}s + 1}, \quad (2.02)$$

where $T_{act} = \frac{1}{K_{act}}$ is actuator time constant, $K_{act} = 20$.

UAV dynamics

$$W_{\delta}^{\omega_z} = \frac{K(T_1s + 1)}{T_2^2s^2 + 2\xi T_2s + 1}, \quad W_{\omega_z}^{\dot{\theta}} = \frac{1}{T_1s + 1}, \quad W_{\dot{\theta}}^{n_y} = \frac{V}{g}, \quad (2.03)$$

Where

$$K = 1,$$

$$T_1 = 0.7 \text{ (s)}, \quad T_2 = 0.5 \text{ (s)},$$

$$\xi = 0.3.$$

1st step - Initial PID coefficients load into Workspace

```
Command Window
>> clear all, close all
>> uiopen('D:\! MATLAB\!GitHub\Control\!done\2_PID\C02_PID_tuning_SISO.slx',1)
>> Kp = 0.35; Kd = -0.65; Ki = 0.06;
fx >> |
```

2nd step - Main characteristics of step response

- Overshoot is calculated is
 $100\% \times [\max(\text{output value}) - \text{final value}] / \text{final value}$.
Recommended value is 15...20%
- Settling time is the time it takes for the output signal to enter the error band)
- Rise time - it depends on inertia characteristics of an UAV

Block Parameters: Check Step Response Characteristics (tuning PID controller) X

Check Step Response Characteristics

Assert that the input signal satisfies bounds specified by step response characteristics.

Bounds Assertion

☒ Include step response bound in assertion

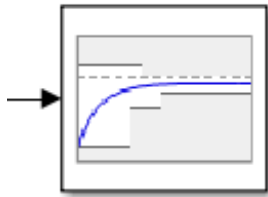
Step time (seconds):	0		
Initial value:	0	Final value:	20
Rise time (seconds):	1	% Rise:	90
Settling time (seconds):	3	% Settling:	1
% Overshoot:	20	% Undershoot:	1

☒ Enable zero-crossing detection

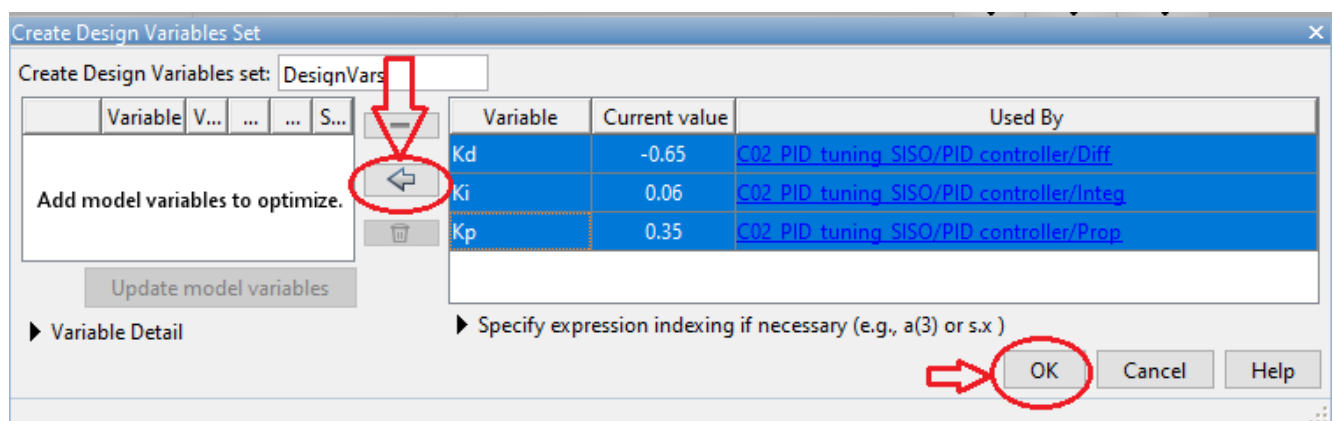
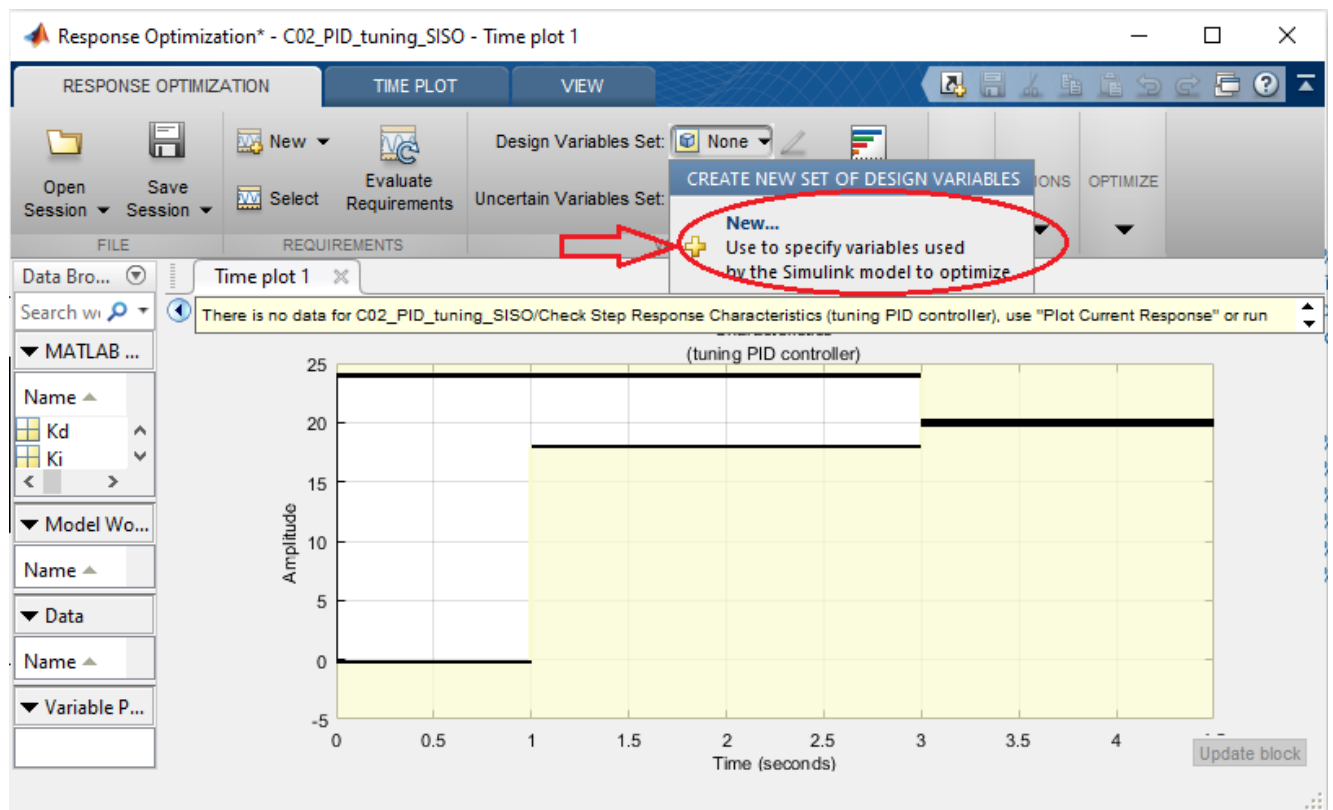
Show Plot ☐ Show plot on block open Response Optimization...

? OK Cancel Help Apply

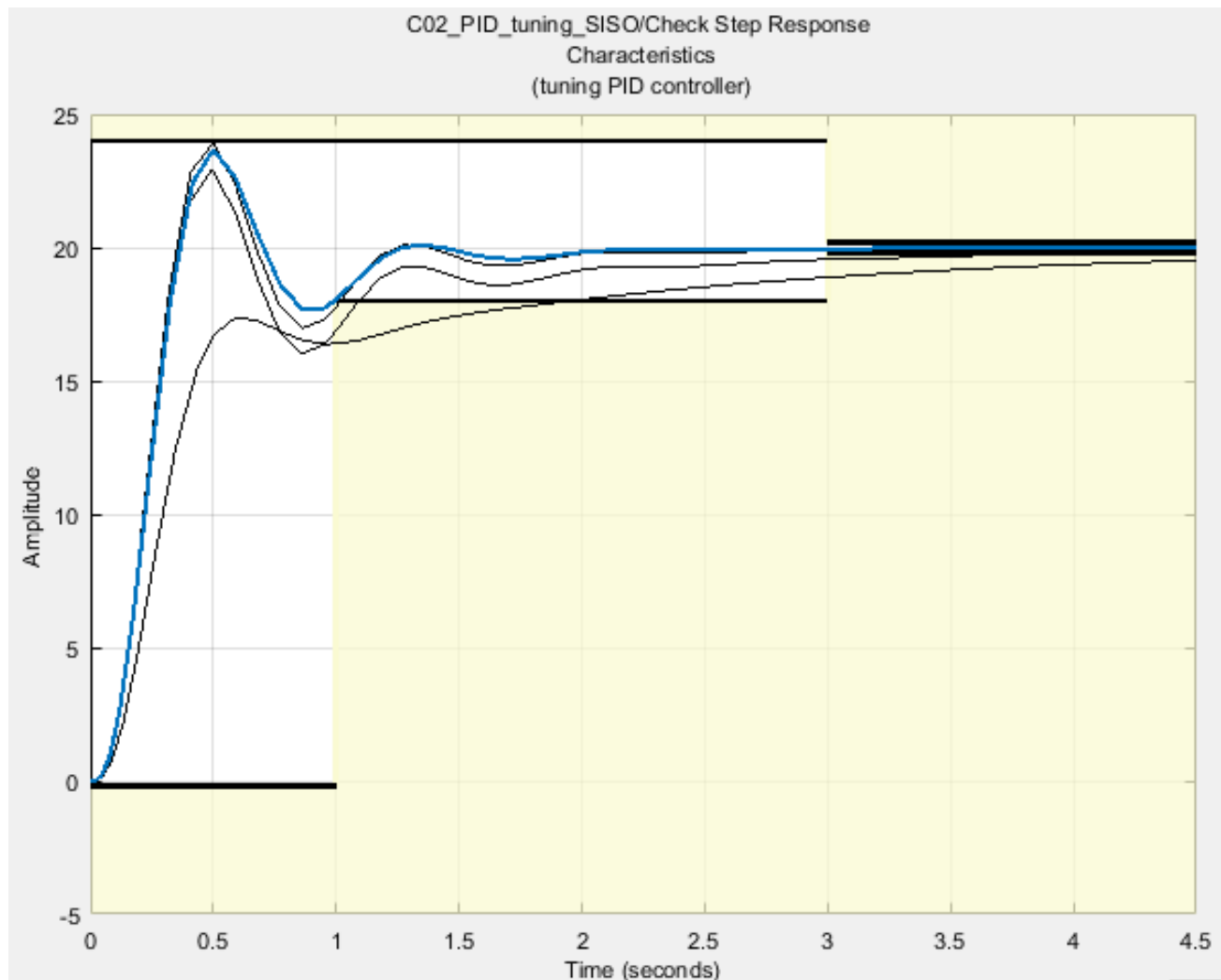
3rd step - Response Optimization setting



Check Step Response
Characteristics
(tuning PID controller)



4th step - Optimize



5th step - Analysis of the optimization results

Optimization Progress Report

Iteration	F-count	Check Step Response Characteristics (tuning PID controller) (Upper) (<=0)
0	7	83.2226
1	14	16.4927
2	21	2.5773
3	28	0.3768
4	35	0.0122
5	42	-0.0025
6	49	-0.0025

Optimized variable values written to 'DesignVars' in the Design Optimization workspace
'C02_PID_tuning_SISO' updated with optimized values
Optimized requirement values written to 'ReqValues' in the Design Optimization workspace

Optimization solver output:

Local minimum found that satisfies the constraints.

Optimization completed because the objective function is non-decreasing in feasible directions to within the selected value of the optimality tolerance.

Save Iteration... Display Options... Optimize

Data Browser

Search workspace variables

MATLAB Workspace

Name	Value
Kd	-2.4934
Ki	0.4485
Kp	0.3115

Model Workspace (C02_PID_tuning_SISO)

Name	Value
sintez_sys_stab_op...	1x1 Sessio...

Data

Name	Value
BlockReq	1x1 BlockR...
DesignVars	3x1 Contin...
ReqValues	1x1 struct

Variable Preview