SISO control design:

In this task we're going to design 3 SISO controllers for our 6-DOF vehicle model. The controllers are:

- Altitude (ie: Z) control
- YAW angle control
- PITCH angle control (NB: the ROLL controller will be identical)

The design requirements for this task are:

Label	Variable to be controlled	STEP response 90% Rise time (secs)	Gain margin (dB)
Altitude control	Y_ze (m)	2.5	60
	Y_ze_dot (m/sec)	0.3	60
Yaw control	Y_phi_yaw (rad)	1.5	60
	Y_phi_dot_yaw_rate (rad/s)	0.25	60
Pitch control	Y_theta_pitch (rad)	0.5	60
	Y_theta_dot_pitch_rate (rad/s)	0.25	60

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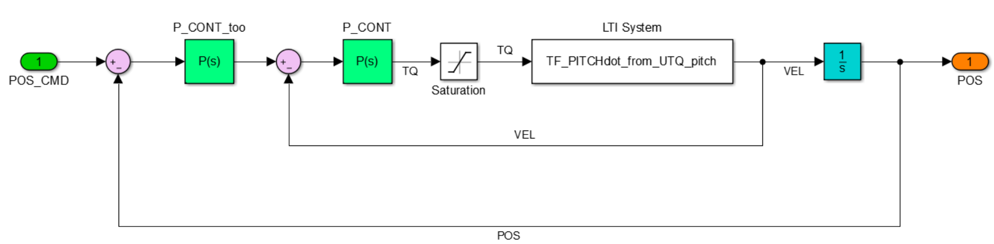
Prerequisite:

Before commencing this task you need to run the **`bh_task_find_trim_and_linearise.mlx`** script to create required variables (eg: transfer function objects) that are used in this control design task.

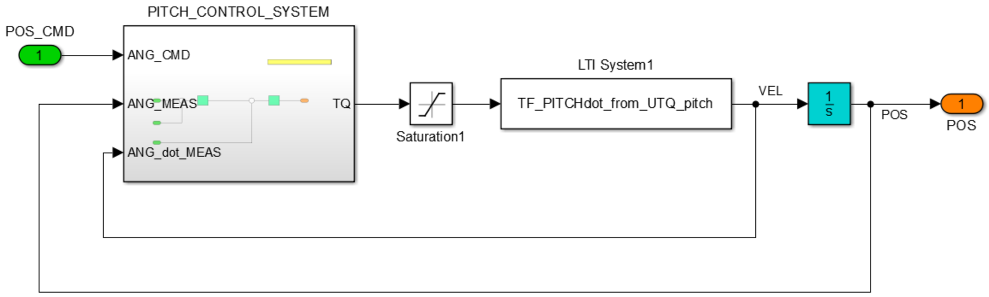
```
assert(1==exist('sys_6dof_lin'), 'you have NOT run the ***bh_task_find_trim_and_linearise***')
```

Our SISO controller structure:

For each of these SISO controllers the structure that we'll use will involve 2 proportional controllers configured in a cascade loop. The inner loop is the velocity loop and the outer loop is the position loop. This control structure is shown below:



Note we can also represent this structure as:



To design each controller we'll design the INNER velocity loop controller first, and then we'll design the OUTER positional controller. The linear plants for each of these 3 control design tasks are:

OUTPUT	Transfer Function	INPUT
Y_ze_dot	$1.079/s$	U_f
Y_phi_dot_yaw_rate	$89.38/s$	U_TQ_phi_yaw_Z
Y_theta_dot_pitch_rate	$171.5/s$	U_TQ_theta_pitch_Y

Create the 3 linear plant transfer functions:

```
TF_ZEdot_from_Uf           = tf(sys_6dof_lin('Y_ze_dot', 'U_f'));
TF_YAWdot_from_UTQ_yaw     = tf(sys_6dof_lin('Y_phi_dot_yaw_rate', 'U_TQ_phi_yaw_Z'));
TF_PITCHdot_from_UTQ_pitch = tf(sys_6dof_lin('Y_theta_dot_pitch_rate', 'U_TQ_theta_pitch_Y'));
```

Echo these:

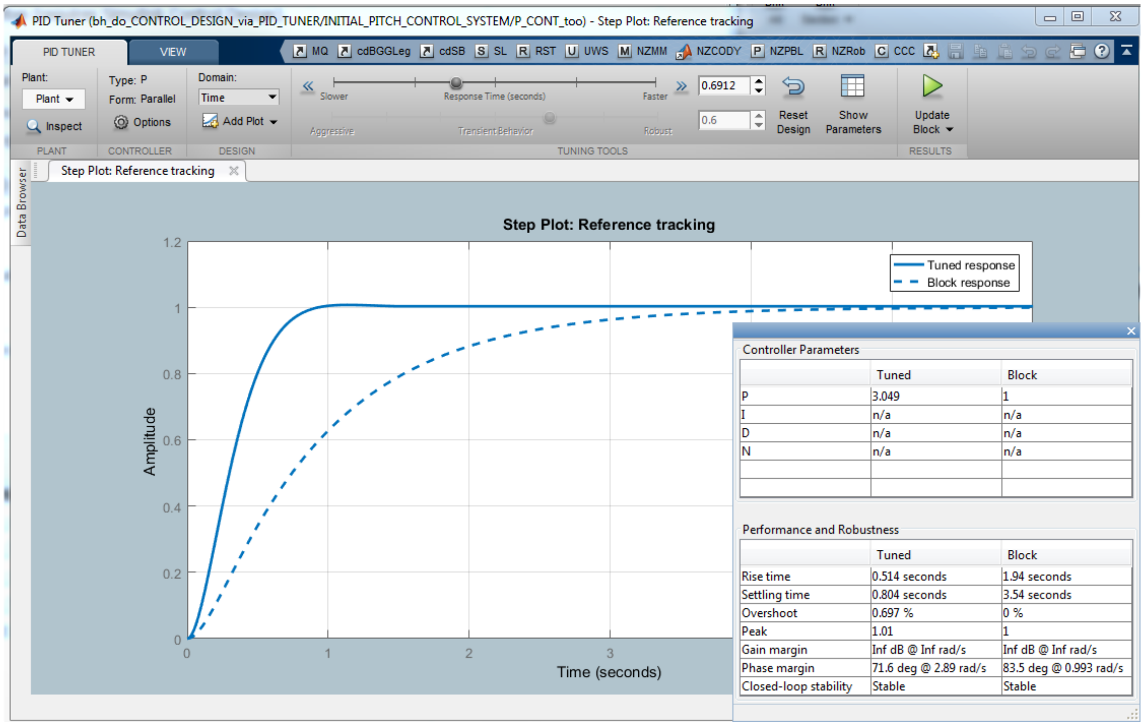
```
[TF_ZEdot_from_Uf,  TF_YAWdot_from_UTQ_yaw, TF_PITCHdot_from_UTQ_pitch ]
```

```
ans =

  From input "U_f" to output "Y_theta_dot_pitch_rate":
  1.079
  -----
    s

  From input "U_TQ_phi_yaw_Z" to output "Y_theta_dot_pitch_rate":
  89.38
  -----
    s

  From input "U_TQ_theta_pitch_Y" to output "Y_theta_dot_pitch_rate":
  171.5
  -----
    s

Continuous-time transfer function.
```

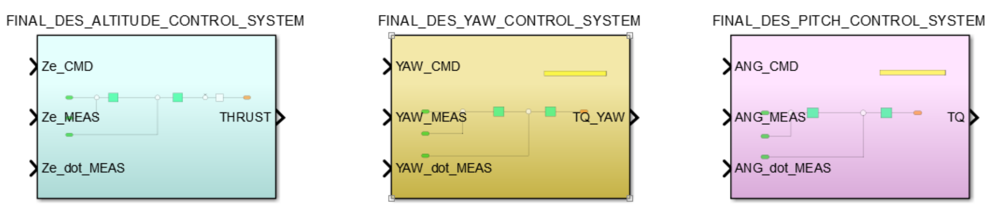
Now do the design:

Open the Simulink model **`bh_do_CONTROL_DESIGN_via_PID_TUNER.slx`** and consider the subsystem called "INITIAL_PITCH_CONTROL_SYSTEM". Launch the PID tuner app for each of the green P blocks and design according to the requirements. NOTE: although all of our designs are just "P-controllers", the tuner app is called the "PID tuner" - hey, no big deal !

```
open_system('bh_do_CONTROL_DESIGN_via_PID_TUNER.slx')
```



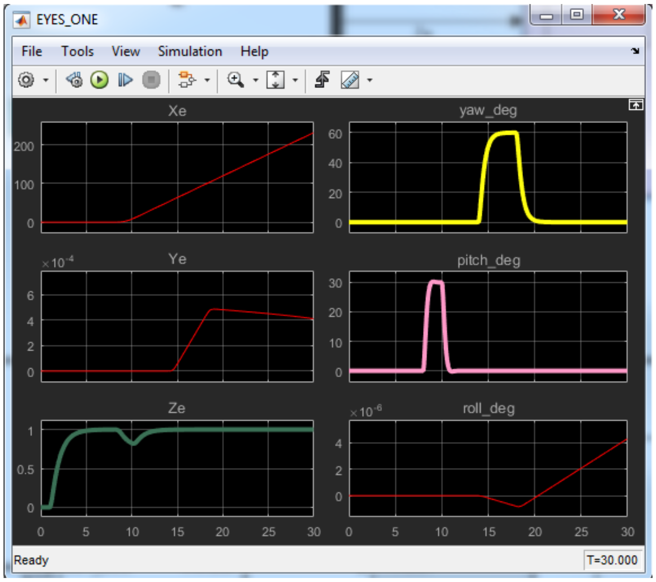
And you can repeat this design for the YAW and ALTITUDE controllers. The final designs that I have made are also shown in the **bh_do_CONTROL_DESIGN_via_PID_TUNER.slx** model, and they are:



But what about the NON-linear 6-DOF model ?

The controllers that we've just designed used a linear approximation of our 6-DOF model.
SO we now need to try the controllers with our NON-linear model. Open the model **bh_test_LINCONT_on_NONLIN_plant.slx** and see how the controllers performed - here we apply STEPS and pulses of:

- Ze = 1 (m)
- Pitch = 30 (degrees)
- YAW = 60 (degrees)

- 
EYES_ONE
File Tools View Simulation Help
Xe
yaw_deg
Ye
pitch_deg
Ze
roll_deg
Ready
T=30.000