Simulation Assignment 3

Rami Wail Shoula, ID: *201600112*
Supervised by: Professor Mohamed Darweesh, Eng Bassant Ibrahim, Eng Ahmed Morsy

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I. Method

A. Phase A - Initialization

```
%Assignment 3 Rami Wail Shoula
%% phase A - Initialize
clc
close all
clear
s=tf('s'); % initialize Transfer Function TF in s domain

```

B. Phase B - Function Definition

```
%% phase B - Function Definition
TF=(s^2+3*s+2.6)/(s^3+ 5.6*s^2+4.9*s+5);
Gain=TF/(1-TF); %closed loop gain
Gain=minreal(Gain);
ess_step = 1/(1+dcgain(Gain))   %steady-state error step

T=feedback(Gain,1);
%obtain damping
damp(T)
%obtain overshoot, undershoot, tr, ts, peak, etc
stepinfo(T)
```

Output from run:

Ess_step, damping frequency, natural frequency, damping ratio, and parameters:

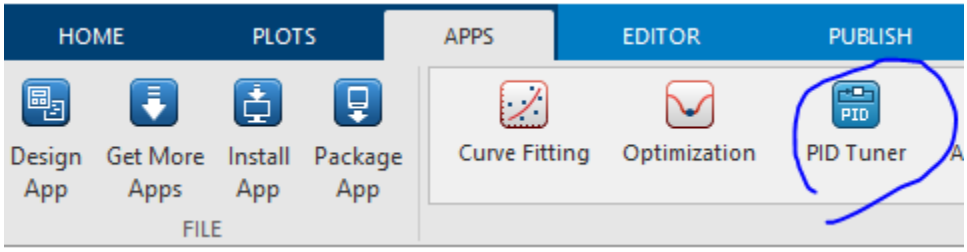
```
ess_step =

    0.4800
```

Pole	Damping	Frequency (rad/seconds)	Time Constant (seconds)
-4.02e-01 + 9.39e-01i	3.94e-01	1.02e+00	2.49e+00
-4.02e-01 - 9.39e-01i	3.94e-01	1.02e+00	2.49e+00
-4.80e+00	1.00e+00	4.80e+00	2.09e-01

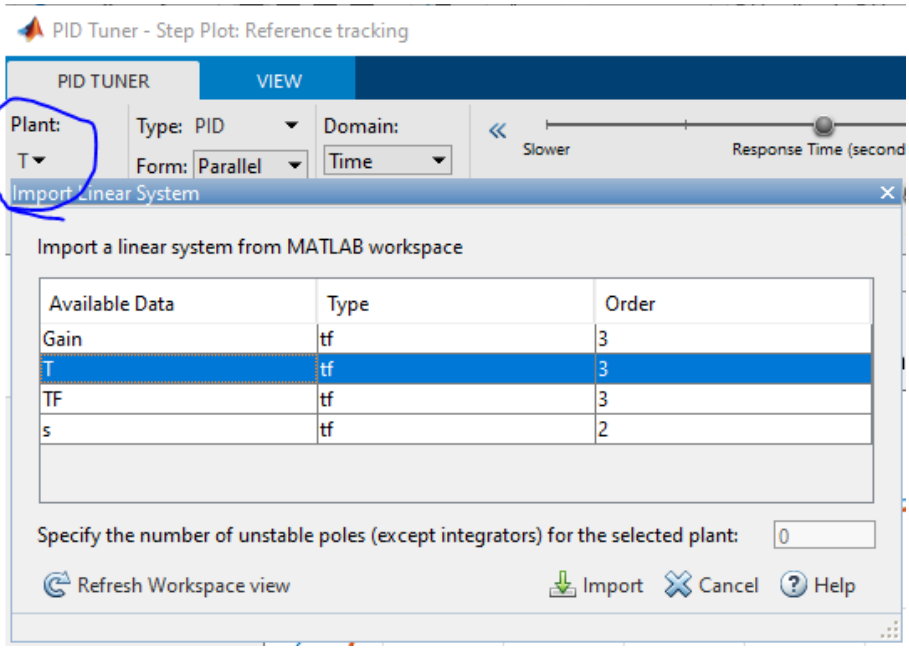
```
ans =

  struct with fields:

       RiseTime: 0.7879
   SettlingTime: 9.5897
    SettlingMin: 0.4685
    SettlingMax: 0.7084
      Overshoot: 36.2344
     Undershoot: 0
           Peak: 0.7084
       PeakTime: 2.2279
```

C. Phase C - PID controller

1) Initialize PID tuner:

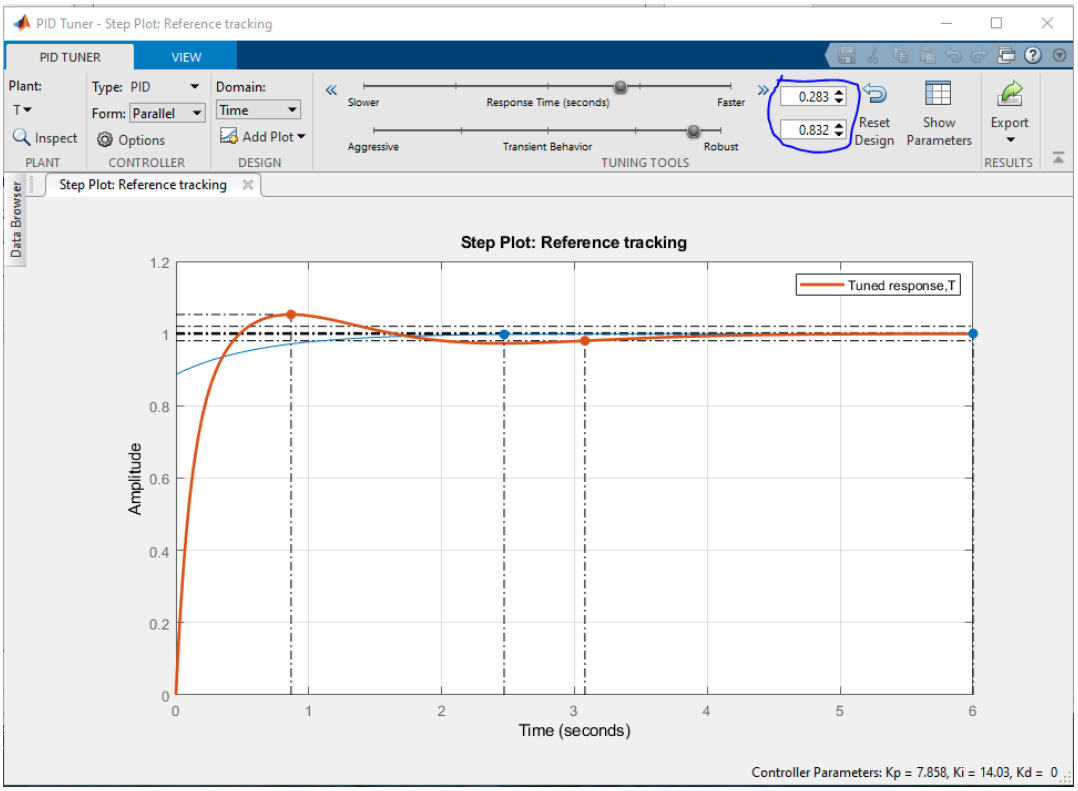


Plant T with base and type PID:



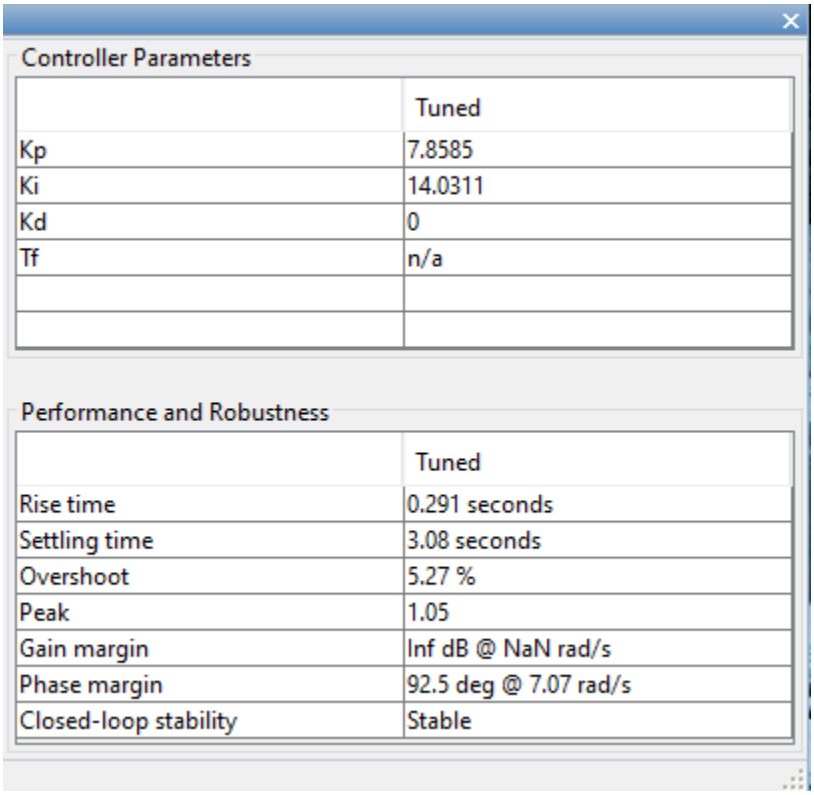
To show both plots: right click on figure -> show plant -> select both. Also check characteristics peak response & settling time (shown).

In order to achieve MP < 5%, Ts = 3 sec, response time and transient response are altered. Following shows final optimum state with MP = 5.27% & Ts =3.08 s:



Tuner values are response time: 0.283 s; transient behavior: 0.832.

Parameters extracted by selecting “show parameters”:



Controller Parameters

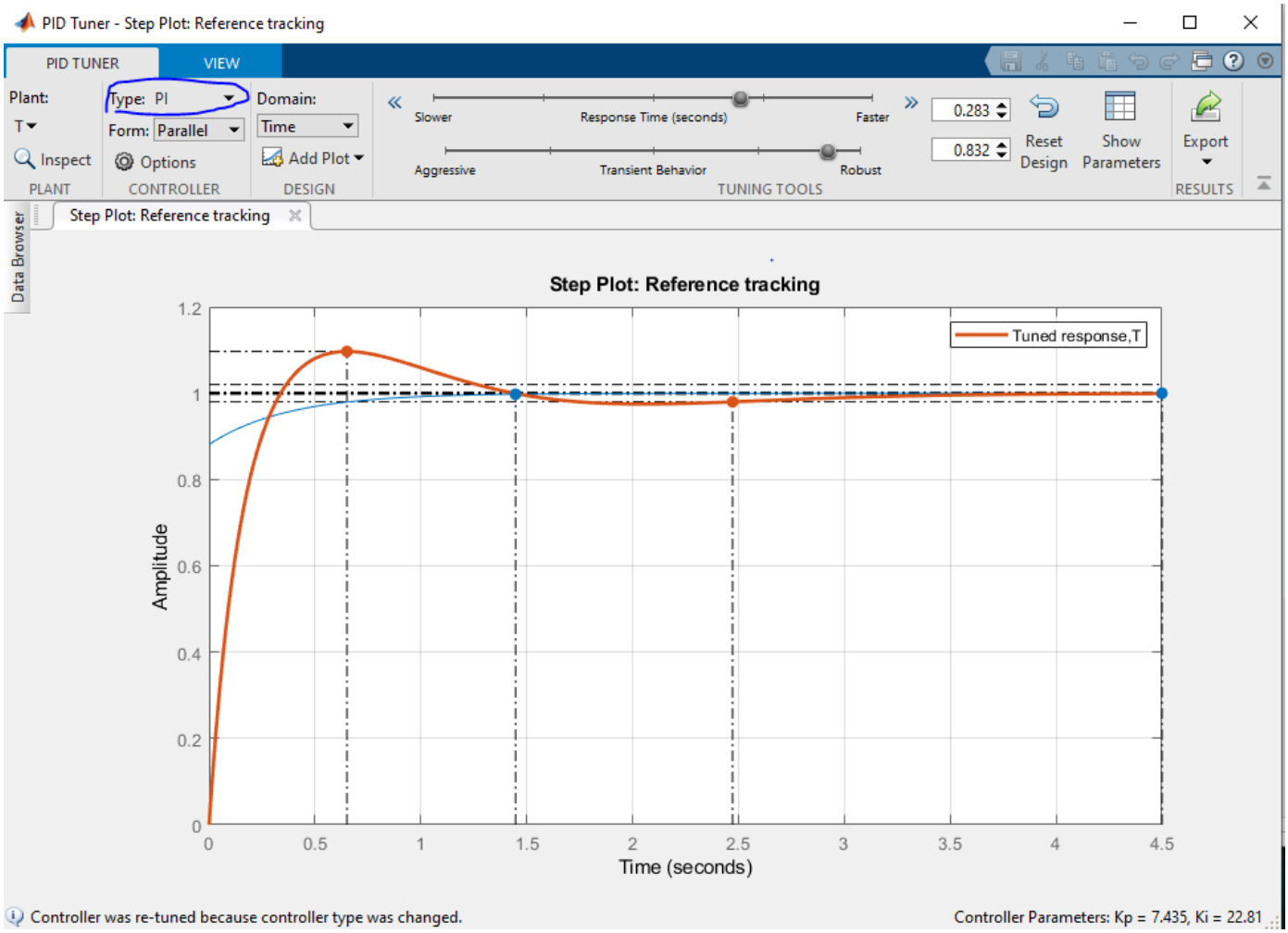
	Tuned
Kp	7.8585
Ki	14.0311
Kd	0
Tf	n/a

Performance and Robustness

	Tuned
Rise time	0.291 seconds
Settling time	3.08 seconds
Overshoot	5.27 %
Peak	1.05
Gain margin	Inf dB @ NaN rad/s
Phase margin	92.5 deg @ 7.07 rad/s
Closed-loop stability	Stable

D. Phase D - PI controller effect

Following shows PI plot and parameters.



Structure of curve(s) similar to PID plot.

Parameters (PID on left, PI on right)

Controller Parameters

	Tuned
Kp	7.8585
Ki	14.0311
Kd	0
Tf	n/a

Performance and Robustness

	Tuned
Rise time	0.291 seconds
Settling time	3.08 seconds
Overshoot	5.27 %
Peak	1.05
Gain margin	Inf dB @ NaN rad/s
Phase margin	92.5 deg @ 7.07 rad/s
Closed-loop stability	Stable

Controller Parameters

	Tuned
Kp	7.435
Ki	22.8111
Kd	n/a
Tf	n/a

Performance and Robustness

	Tuned
Rise time	0.234 seconds
Settling time	2.47 seconds
Overshoot	9.68 %
Peak	1.1
Gain margin	Inf dB @ NaN rad/s
Phase margin	83.2 deg @ 7.07 rad/s
Closed-loop stability	Stable

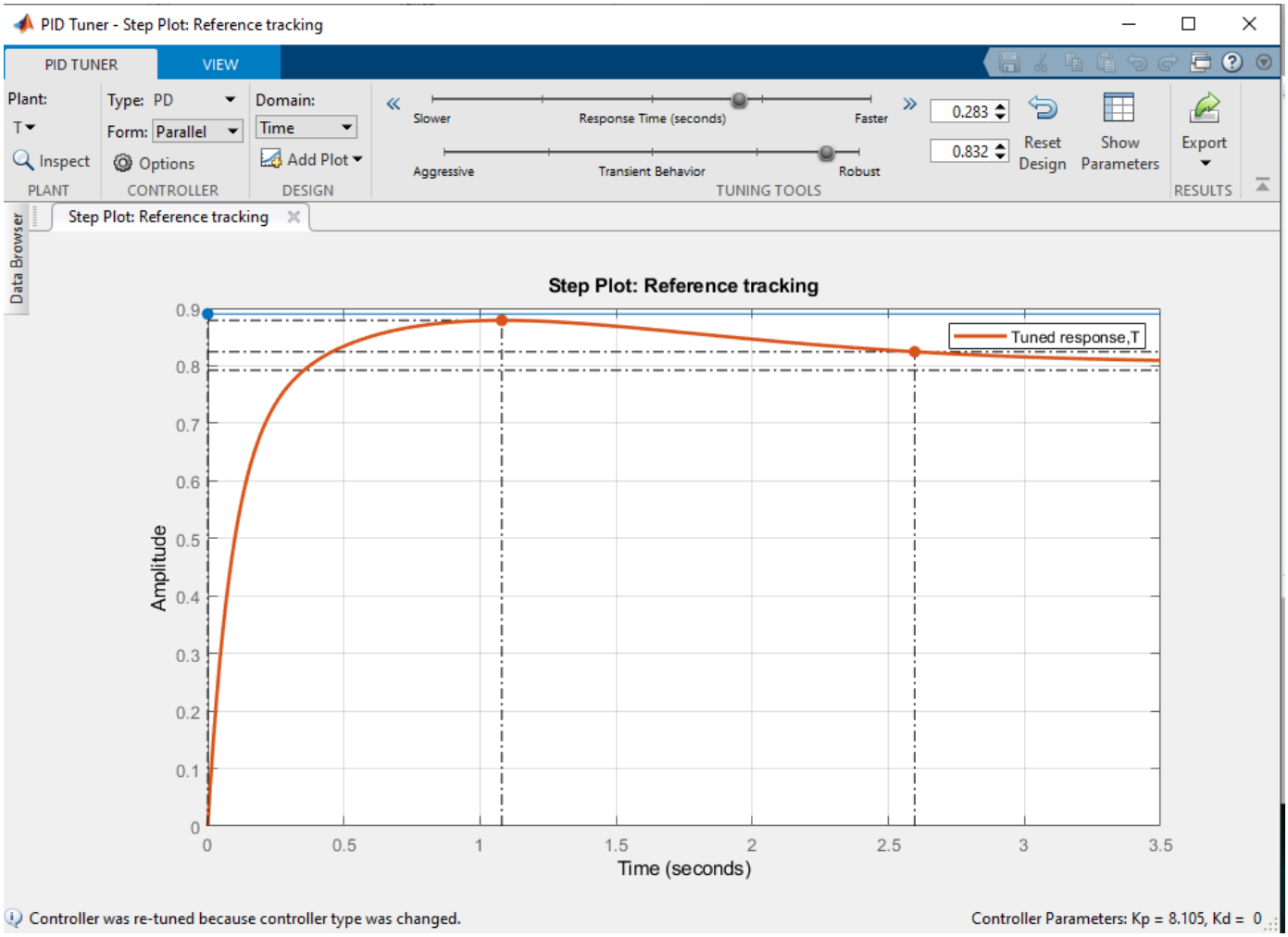
Comparing to PID values and plot:

PI only results in higher Ki value (22.8111 instead of 14.0311), but lower Kp value (7.435 instead of 7.8585), while Kd value is not calculated.

For performance: PI has: Lower tr and ts, higher overshoot & peak, lower phase margin.

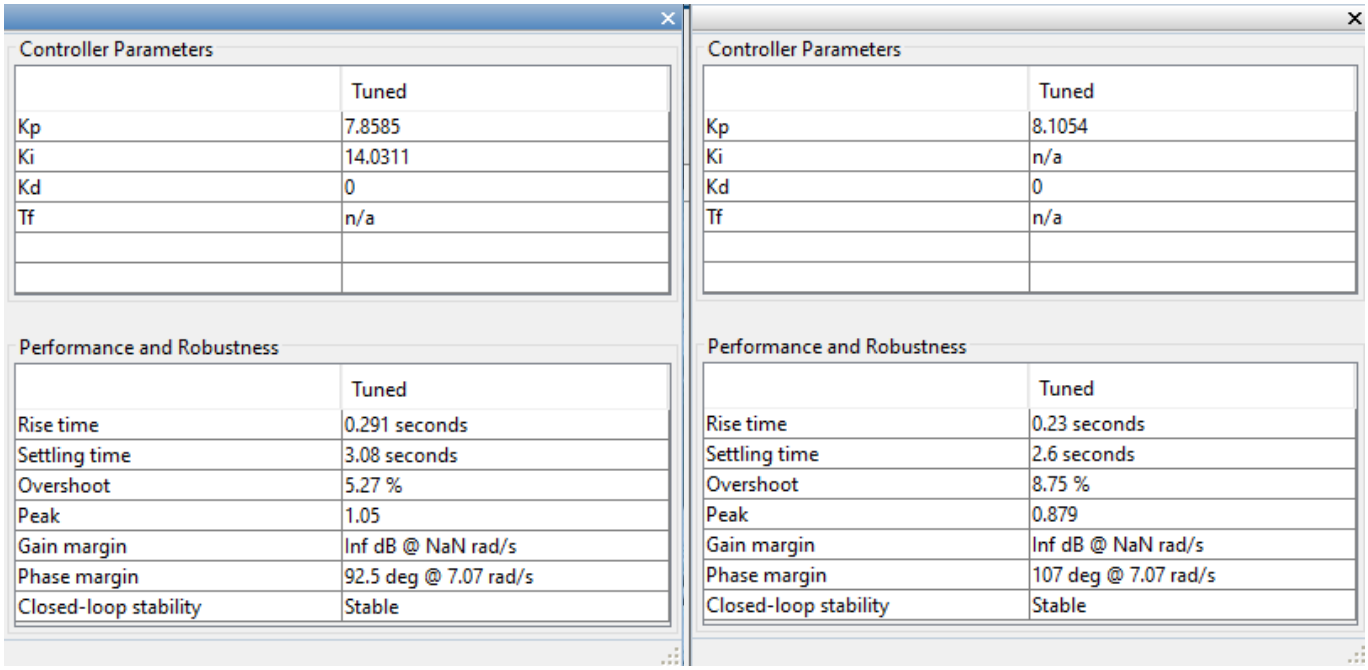
E. Phase E – PD controller effect

Following shows PD plot and parameters.



Structure of curve(s) different from PID plot.

Parameters (PID on left, PD on right)



Controller Parameters

	Tuned
Kp	7.8585
Ki	14.0311
Kd	0
Tf	n/a

Performance and Robustness

	Tuned
Rise time	0.291 seconds
Settling time	3.08 seconds
Overshoot	5.27 %
Peak	1.05
Gain margin	Inf dB @ NaN rad/s
Phase margin	92.5 deg @ 7.07 rad/s
Closed-loop stability	Stable

Controller Parameters

	Tuned
Kp	8.1054
Ki	n/a
Kd	0
Tf	n/a

Performance and Robustness

	Tuned
Rise time	0.23 seconds
Settling time	2.6 seconds
Overshoot	8.75 %
Peak	0.879
Gain margin	Inf dB @ NaN rad/s
Phase margin	107 deg @ 7.07 rad/s
Closed-loop stability	Stable

Kp value is higher.

For performance: PD has: Lower tr and ts, higher overshoot, lower peak, higher phase margin.