Control Systems

Lab Assessment #1

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Objective:

To understand and analyse the impact of parameters in following forms of feedback on a simple system

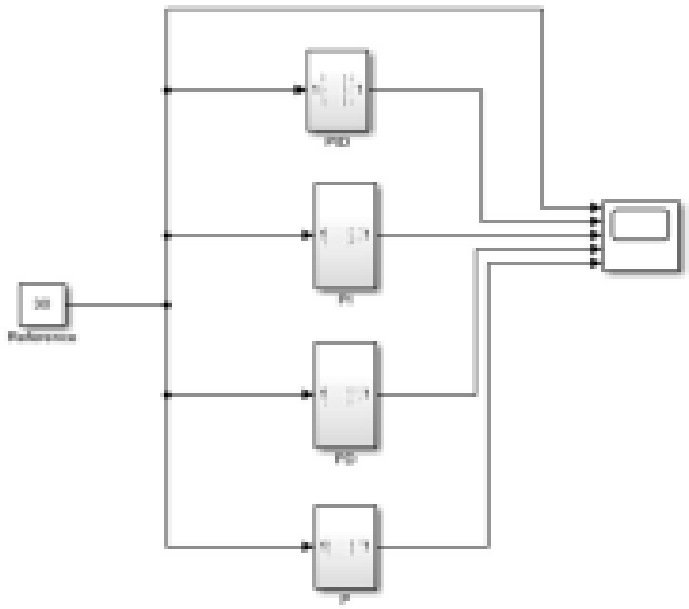
1. Proportional Control
2. Proportional Derivative Control
3. Proportional Integral Control
4. Proportional Integral Derivative Control

Experiment Design:

As given, we considered an Automatic Cruise Control of a Car. According to the given parameters, the excitation function can be given by

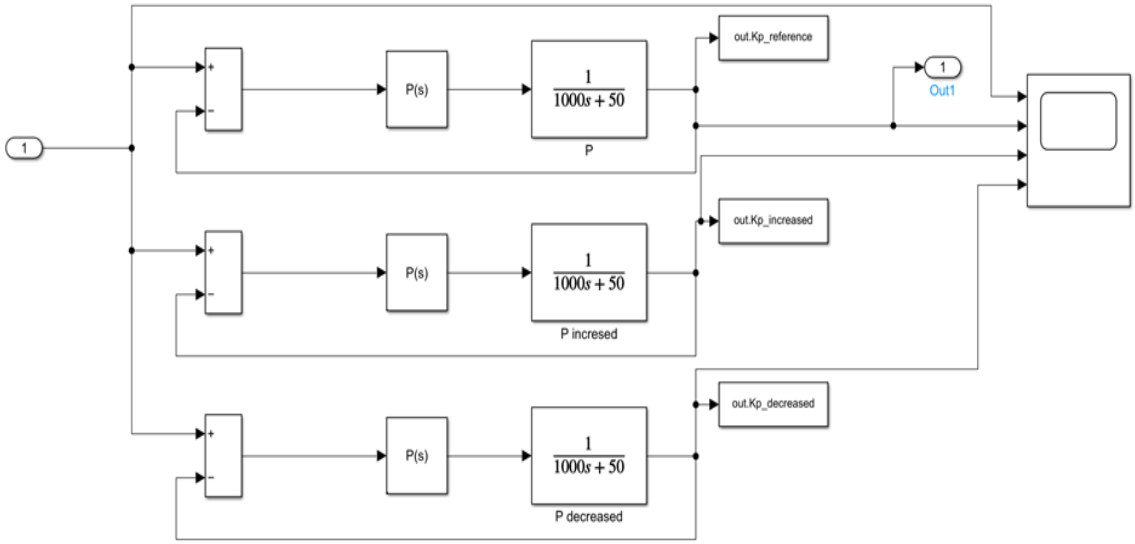
$$G(s) = \frac{1}{1000s + 50}$$

Let us consider a target speed of 30 (units understood). Each controller was modelled and packed inside a subsystem in Simulink as below.



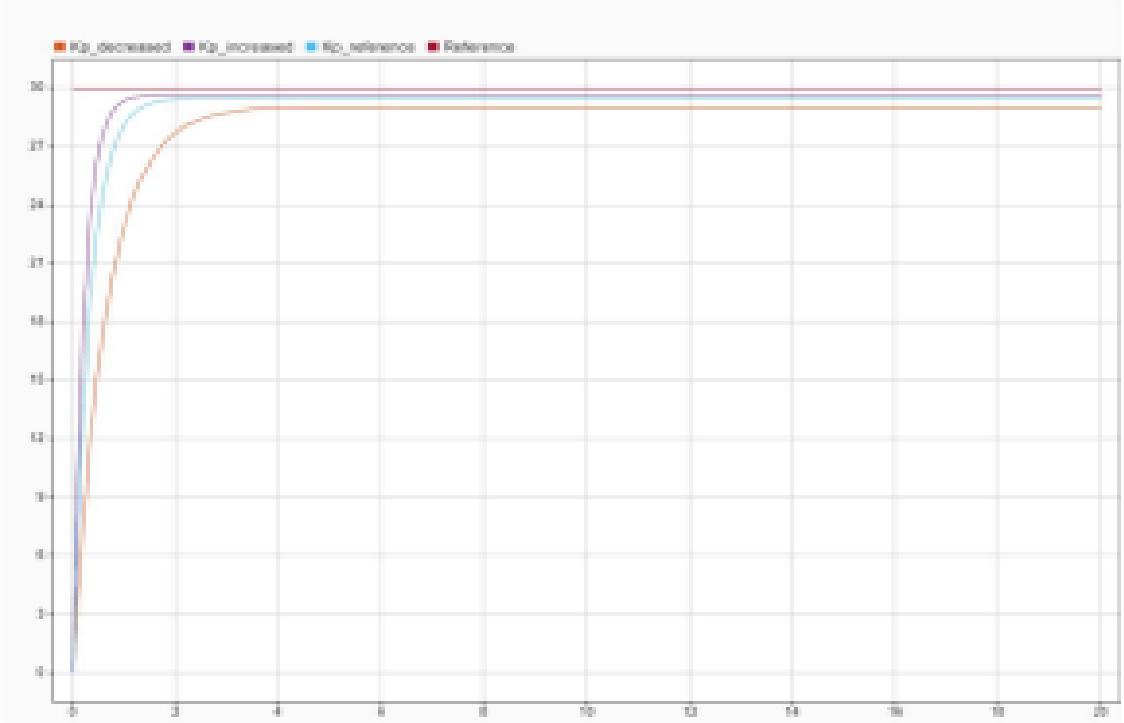
1. **Proportional Control**:

Model:



Observations:

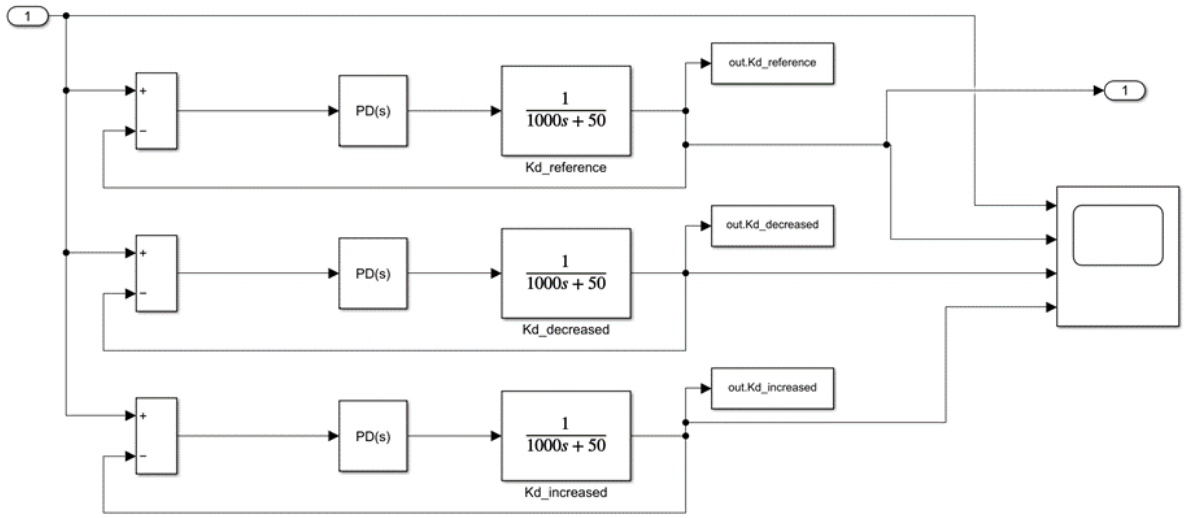
The results are as follows when the model is simulated for 20s



a. We can observe that when Kp is decreased, the saturation value decreases too.
b. With lower Kp, the time taken to reach the value too increases.
c. With the higher Kp the time taken for saturation is less.
d. The saturation value with the higher Kp is close to the reference required.
e. With lower Kp, the error is more when compared to higher case.

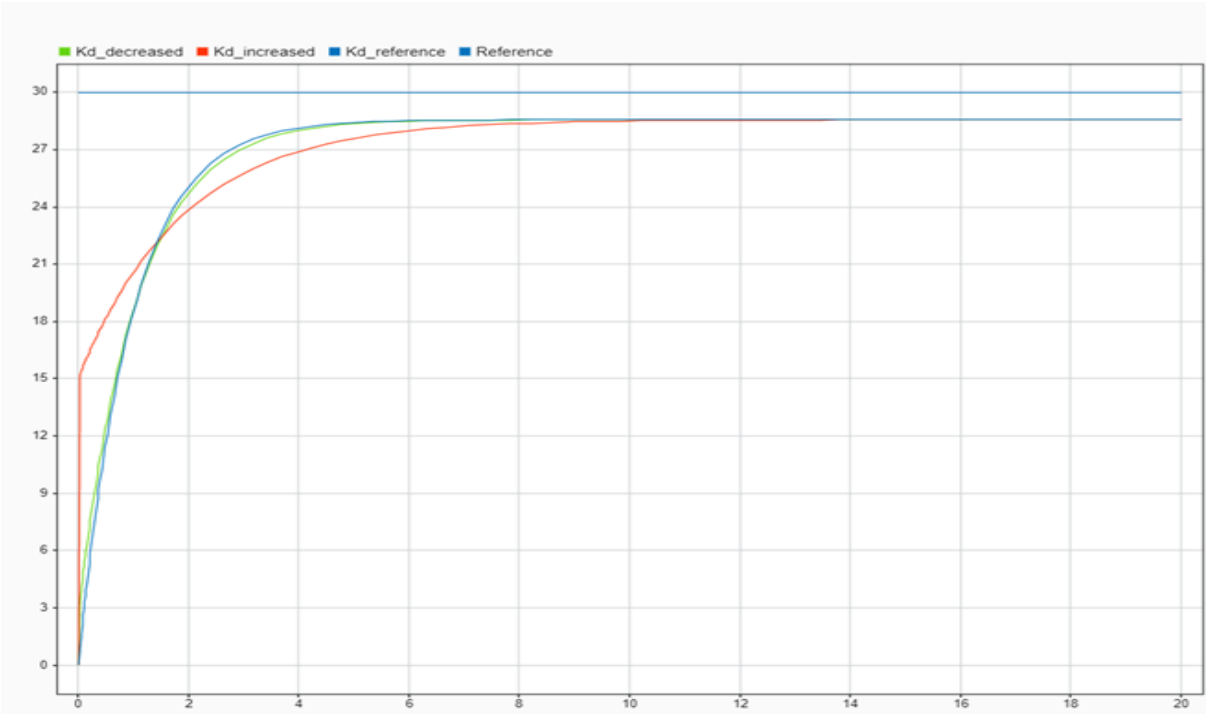
2. Proportional Derivative Control:

Model:



Observations:

The results are as follows when the model is simulated for 20s



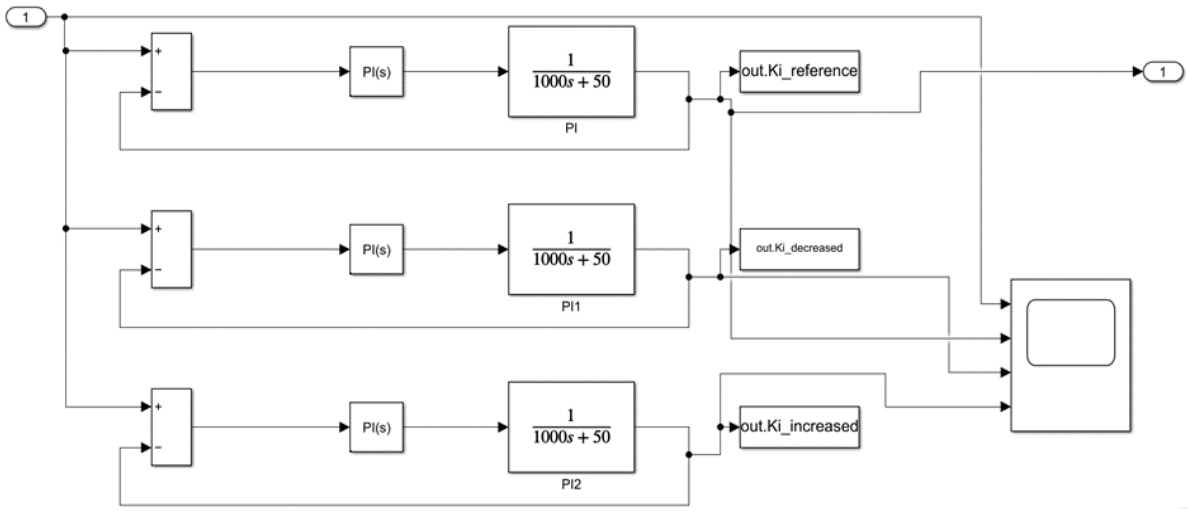
a. We can observe that the increase in Kd increases the slope of the curve, i.e. the settlement duration becomes less.

b. Seeing the values we can infer that for better increase, we need to increase Kd in a considerable amount than Kp.

c. The settled final saturation is nearly the same in all the three cases, which depicts the significance of Kd in error and saturation value.

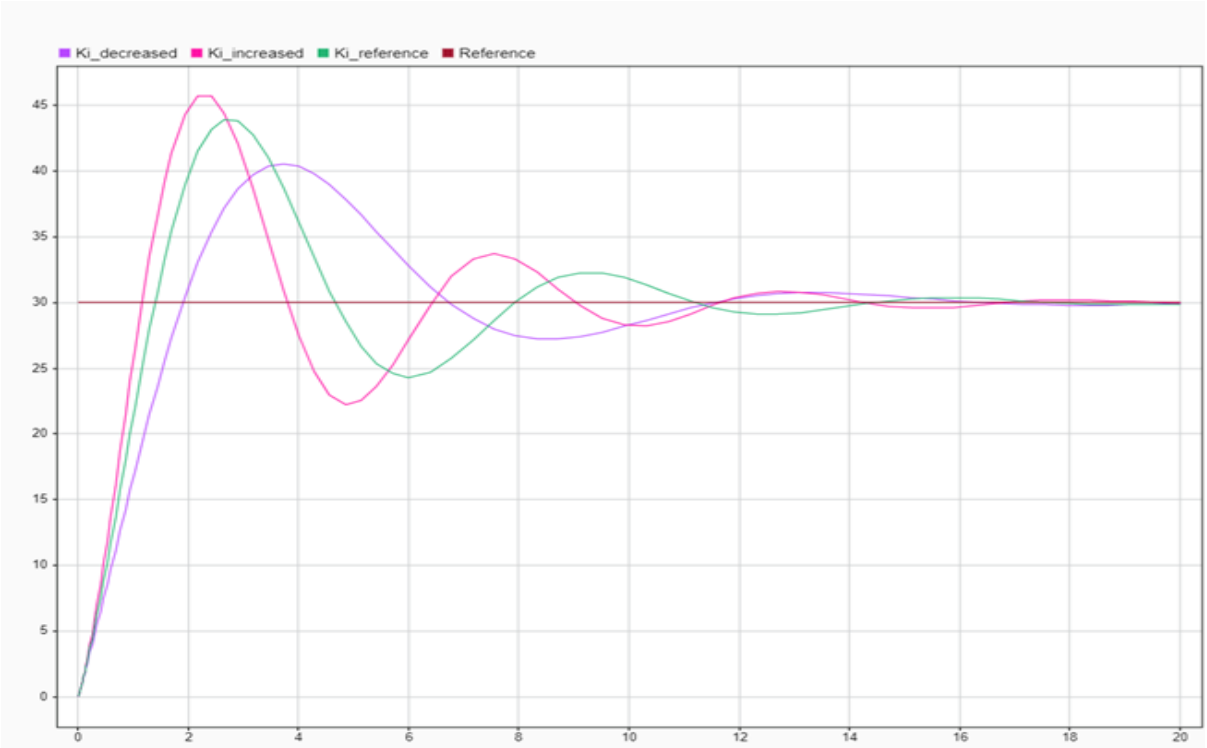
3. Proportional Integral Control:

Model:



Observations:

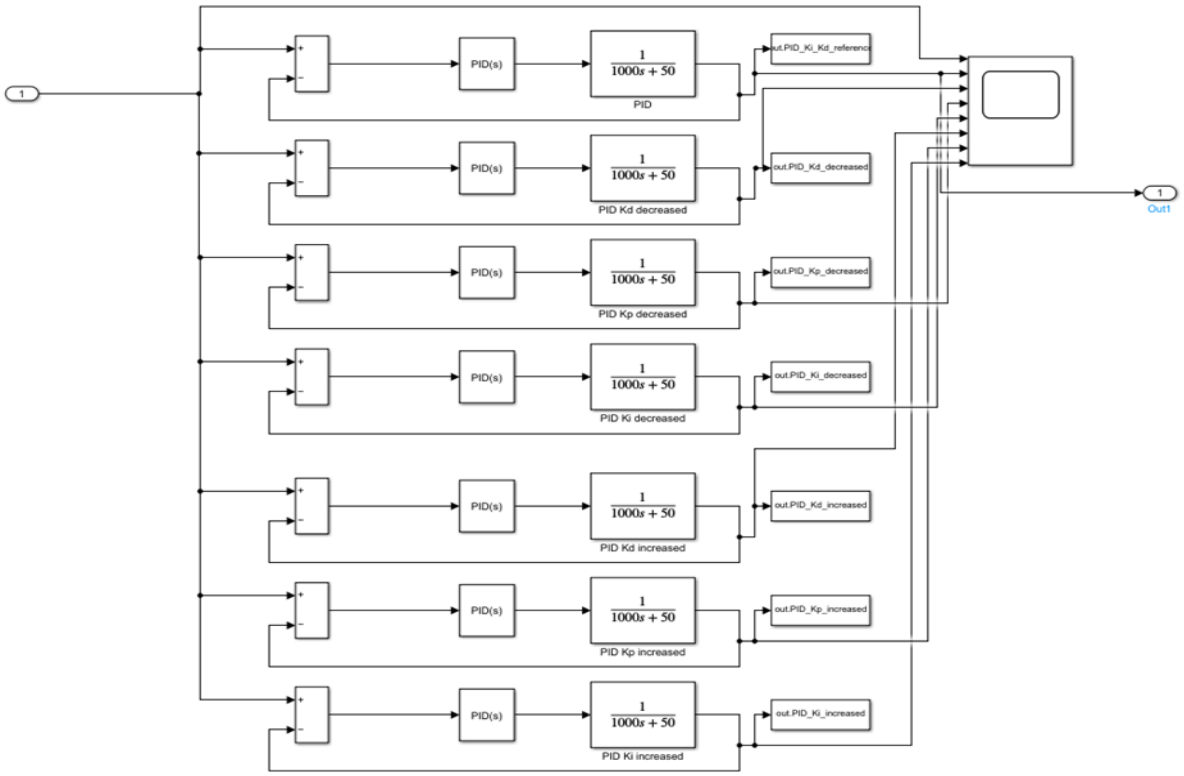
The results are as follows when the model is simulated for 20s



a. The overshoot and oscillations are common in these PI controllers.
b. The amplitude of the first shoot up (rise amplitude) increases wrt Ki value.
c. The signal with higher Ki has a lesser oscillation period (damping included).
d. The settlement time is equivalent for all the cases when we consider a significant range (95% of standard reference).

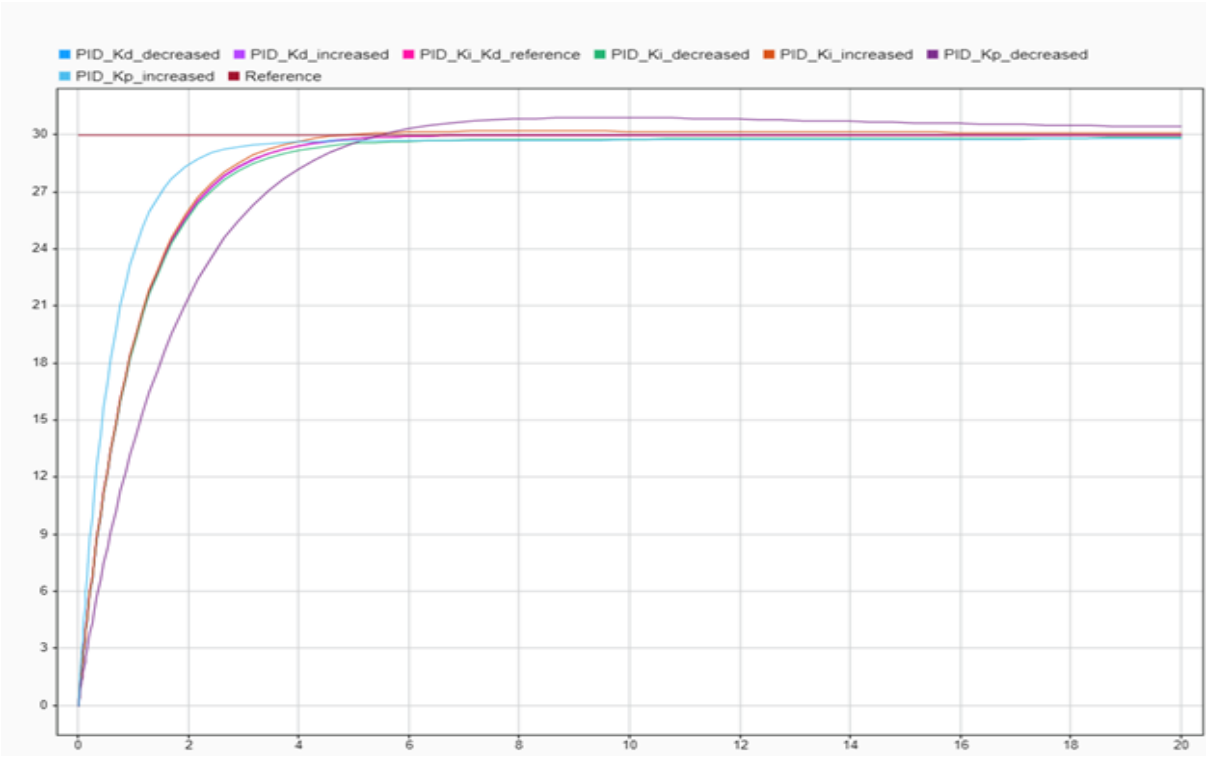
4. Proportional Integral Derivative Control:

Model:



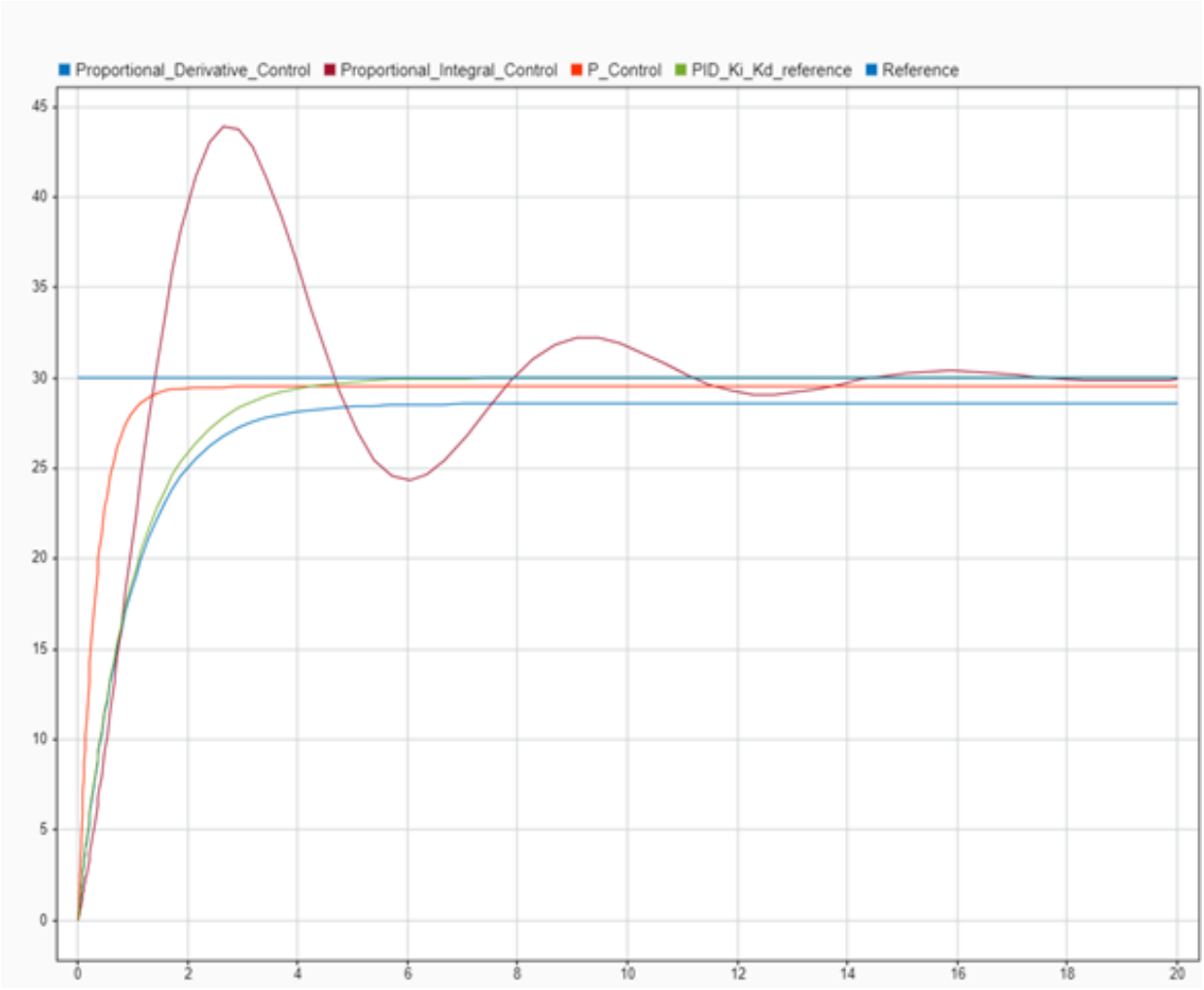
Observations:

The results are as follows when the model is simulated for 20s



a. We can observe that all of these follow similar trends but with different settle values after saturation at steady state.
b. As Kd is increased, there is overflow (more than required target) in this case.
c. With increase in Kp, the slope of the transition curve increases which suggests that the system will settle in lesser duration.
d. The Ki increased case seems to be the best optimal control for our requirement with optimal transition duration and minimum error.

Combined Plot:



Plot containing all the controls Proportional, Proportional Derivative, Proportional Integral, Proportional Integral Derivative control.

Improvements:

1. We can improve the present model by adding the sliders and continuous plot updating script for fine-tuning the model with the optimum results.
2. The filter parameter too can be properly utilised for the suppression of damping and overshooting, where we get the optimal error at the end.