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Lab 08
Proportional-Integral & Proportional-Derivative Controllers for Motor Speed and Position Control

8.1 Objective
To investigate the characteristics of Proportional-Integral (PI) and Proportional-Derivative (PD) Controllers and design PI controller and PD controllers based on time domain specifications for the DC motor speed and position control, respectively.

8.2 Required Files

LabVIEW with Control Design & Simulation	
QUBE Servo	**QNET DC Motor**
NI myRIO 15.0	NI DAQmx
QUBE-Servo-2.Ivproj	NI ELVISmx
QUBE-Servo 2 Second Order.vi with sub-Vis QUBE Servo 2 Position Control.vi	QNET-Motor-Second-Order.vi with sub-Vis QNET-Motor-Position-Control.vi

8.3 Introduction
In Lab 07, we controlled the position of DC motor using feedback. The controller used was a simple proportional controller with gain K_P. In this lab, we will be investigating the operation of other two controllers; proportional-integral and proportional-derivative controllers.
In a feedback control system, the controller manipulates the error signal, generated by the comparison of the set-point and output, to produce an input for the plant, called the control signal $u(t)$, which is needed to drive the process variable toward the desired set-point.

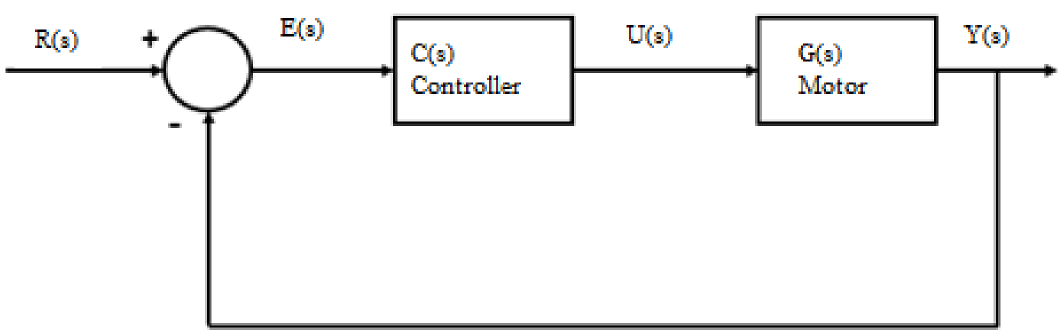


Figure 1: DC Motor with unity feedback control

PID controllers are one of the most widely used controllers in present day and have been in use since the 1920s. A PID controller generates a control signal that is sum of **three** terms, each obtained by applying a different operation on the error signal $e(t)$.
Mathematically, the control action from a PID controller is given as

$$u(t) = K_P e(t) + K_I \int_0^t e(t)dt + K_D \frac{d}{dt} e(t)$$

Where K_P, K_I and K_D are referred to as the **proportional**, **integral**, and **derivative control gains**, respectively. The above controller equation can be described by the transfer function:

$$C(s) = K_P + \frac{K_I}{s} + K_D s$$

The corresponding block diagram is given in Figure 2.

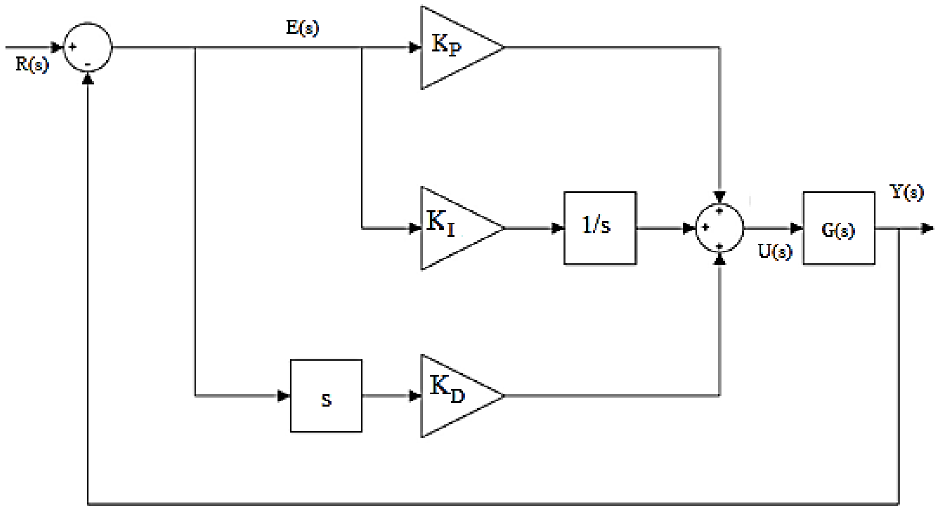


Figure 2: Block diagram of a PID controller

The proportional part of controller could be seen as representing ***present*** since it generates a control signal proportional to the current value of error. The integral part represents the ***past*** as it generates a control signal based on the integral of error signal i.e., sum of instantaneous error over time and therefore, responds to accumulated errors from past. The derivative represents the ***future*** as it works on the rate of change of error and generates a control action based on error prediction.

When K_D and K_I are kept zero with non-zero K_P, the controller is called a ***Proportional (P) Controller***. When K_D is zero and the controller has only proportional and integral terms, then it is called a ***Proportional-Integral (PI) Controller***. Similarly, a ***Proportional-Derivative (PD) Controller*** can be implemented by setting K_I zero.

Task 1: To find closed-loop transfer function and steady-state error of DC motor speed control system with a PI-Controller

The transfer function representing the DC motor speed-voltage relationship with steady-state gain K and time constant τ is given by $G(s) = \frac{Y(s)}{U(s)} = \frac{K}{\tau s + 1}$.

1. For the unity-feedback closed loop system shown in figure 1, find the expression of $E(s)$ in terms of $R(s)$, $C(s)$ and $G(s)$.

(1) $C(s) = \frac{U(s)}{E(s)} \Rightarrow U(s) = C(s)\,E(s)$

$$G(s) = \frac{Y(s)}{U(s)}$$

$$Y(s) = R(s)-E(s) = R(s) - E(s)$$

$$G(s) = \frac{R(s)-E(s)}{U(s)}$$

$$G(s) = \frac{R(s)-E(s)}{C(s)\,E(s)}$$

$$G(s)\,C(s)\,E(s) + E(s) = R(s)$$

$$E(s)\big(G(s)C(s)+1\big) = R(s)$$

$$\boxed{E(s) = \frac{R(s)}{G(s)\,C(s)+1}}$$

(2)

2. Find the steady-state error when the controller is proportional controller with gain K_P. To calculate steady-state value of error $e(t)$, you can apply the Final Value Theorem which can be defined as
$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} s\,F(s)$$

2) $E(s) = \dfrac{1/s}{\left(\frac{K}{Ts+1}\right)(K_p)+1}$ $\quad C(s) = K_p$ proportional controller

By final value theorem

$$= \lim_{s\to 0} s\left[\frac{1/s}{\left(\frac{K}{Ts+1}\right)K_p + 1}\right]$$

Applying limit

$$e(\infty) = \frac{1}{KK_p+1}$$

3. Find the steady-state error when the controller is an integral controller with integral control gain K_I.

(3) $C(s) = K_I$

$$E(s) = \frac{1/s}{\left(\frac{K}{Ts+1}\right)\left(\frac{K_I}{s}\right)+1} = \frac{1/s}{\frac{KK_I}{Ts^2+s}+1}$$

$$E(s) = \frac{1/\cancel{s}}{\frac{KK_I+Ts^2+s}{\cancel{s}(Ts+1)}}$$

$$E(s) = \frac{(Ts+1)}{(KK_I+Ts^2+s)}$$

Applying final value theorem

$$e(\infty) = \lim_{s \to 0} s \frac{(Ts+1)}{KK_I+Ts^2+s}$$

$$= \lim_{s \to 0} 0 \frac{(1)}{KK_I}$$

Applying limit $e(\infty) = 0$

~~App~~

4. In Figure 1, if the controller is a PI controller with $C(s) = K_P + \frac{K_I}{s}$. What is the closed loop transfer function $T(s)$ of the speed control system? Compare it with the standard characteristic polynomial $s^2 + 2\zeta\omega_n + {\omega_n}^2$ and obtain the expressions for K_P and K_I in terms of ζ and ω_n.

(4) $C(s) = K_p + \frac{K_I}{s}$

$$T(s) = \frac{C(s)\,G(s)}{1 + C(s)\,G(s)}$$

$$= \frac{K_p + \frac{K_I}{s}\,G(s)}{1 + \left(K_p + \frac{K_I}{s}\right) G(s)}$$

$$= \frac{K_p + \frac{K_I}{s}\left(\frac{K}{Ts+1}\right)}{1 + \left(K_p + \frac{K_I}{s}\right)\left(\frac{K}{Ts+1}\right)}$$

$$= \frac{K_p + \frac{K_I K}{Ts^2 + s}}{1 + \frac{K K_p}{Ts+1} + \frac{K_I K}{s(Ts+1)}}$$

$$= \frac{s(Ts+1)k_p + k_I k}{s(Ts+1) + kk_p s + k_I k}$$

$$= \frac{s(Ts+1)k_p + k_I k}{Ts^2 + s(1+kk_p) + k_I k}$$

$$= \frac{(Ts^2+s)k_p + k_I k}{Ts^2 + s(1+kk_p) + k_I k}$$

$$= \frac{Ts^2 k_p + s k_p + k_I k}{Ts^2 + s(1+kk_p) + k_I k}$$

$$= \frac{s^2 + s/T + \frac{k_I k}{T k_p}}{s^2 + \frac{s(1+kk_p)}{T} + \frac{k_I k}{T}}$$

$$\omega_n^2 = \frac{k_I k}{T}$$

$$\omega_n = \sqrt{\frac{K_I k}{T}}$$

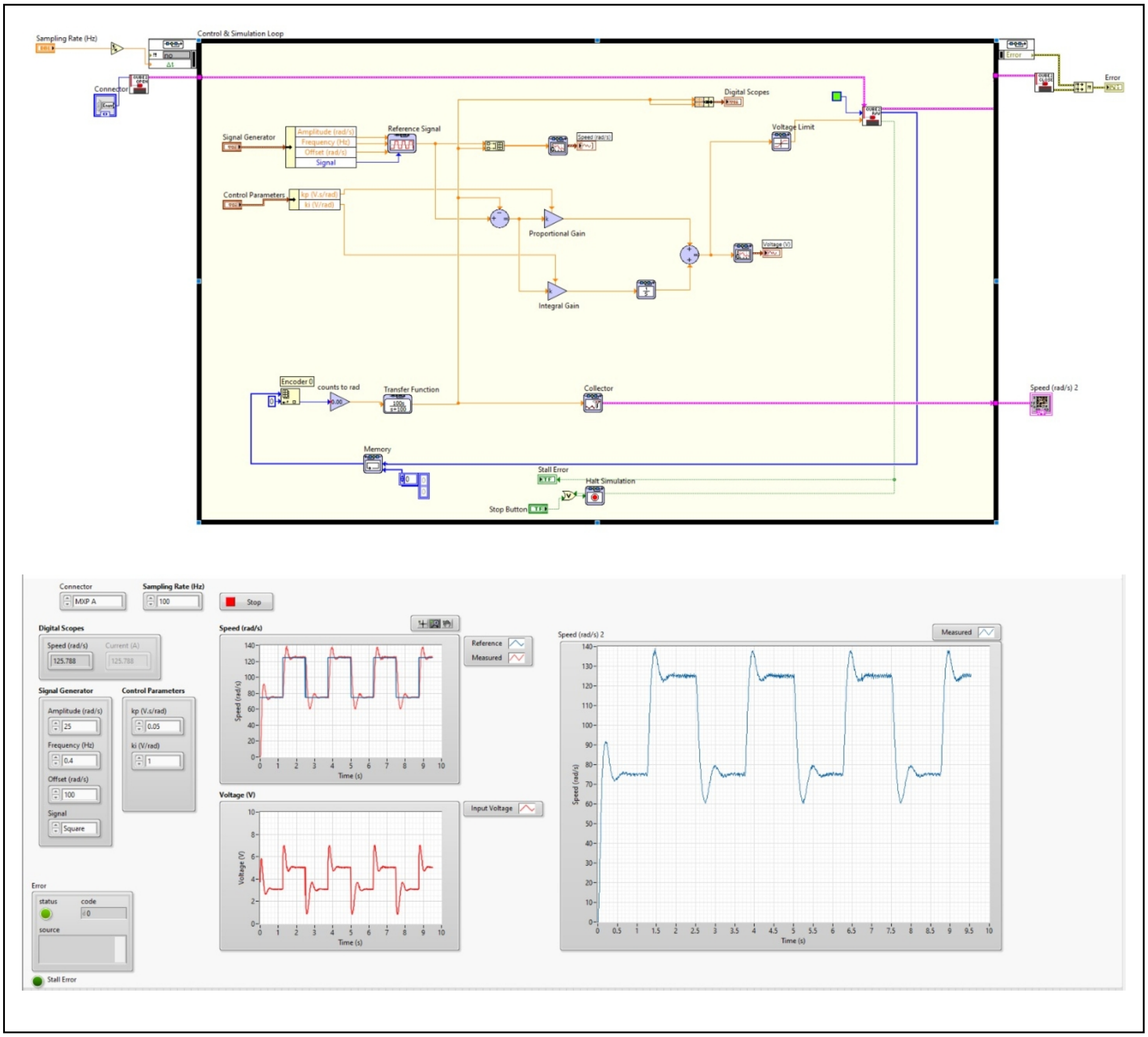
$$2\zeta\omega_n = \frac{(1+kk_p)}{T}$$

$$2\zeta\sqrt{\frac{k_I k}{T}} = \frac{1+kk_p}{T}$$

$$\zeta = \frac{1+kk_p}{2T} \times \sqrt{\frac{T}{K_I k}}$$

Task 2: To implement a PI controller for DC Motor speed control system

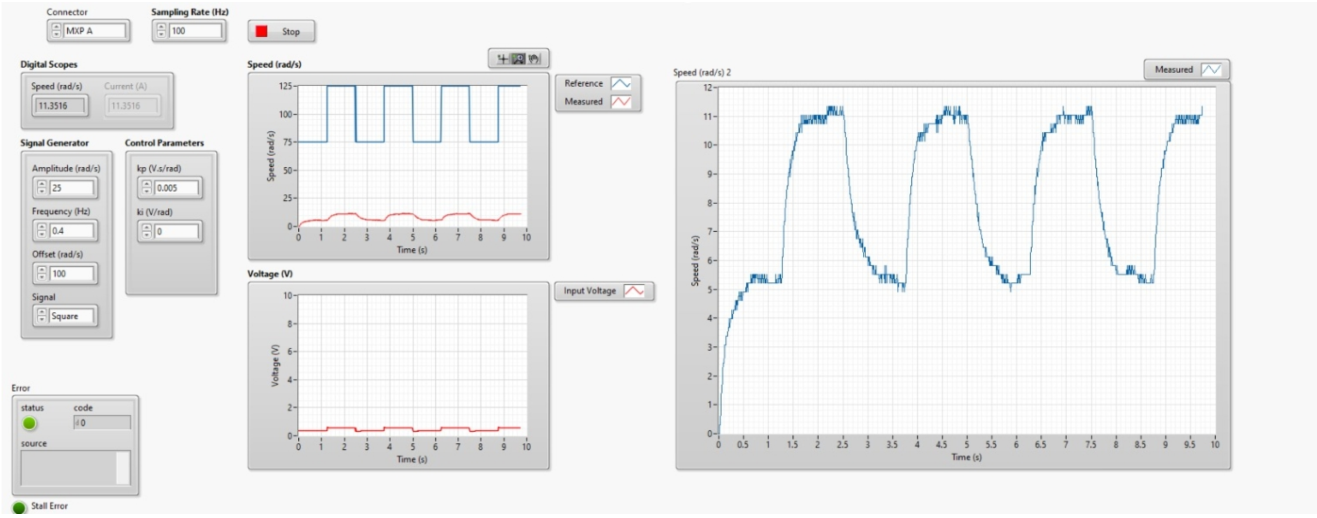
1. Use the VI (Speed Control.vi) provided on LMS and modify it such that the output to be controlled is now motor speed instead of motor position. Give square wave input from signal generator with 0.4 Hz frequency and amplitude 25 with offset of 100. Don't forget to add the saturation block and bundle the input and output to display on the same waveform.
2. Now, add blocks to implement the PI controller. You will need Gain blocks to control the proportional and integral control gains (K_P and K_I.) and an integrator block to integrate the error signal. Create controls for K_P and K_I. Add the capture of the implemented VI.



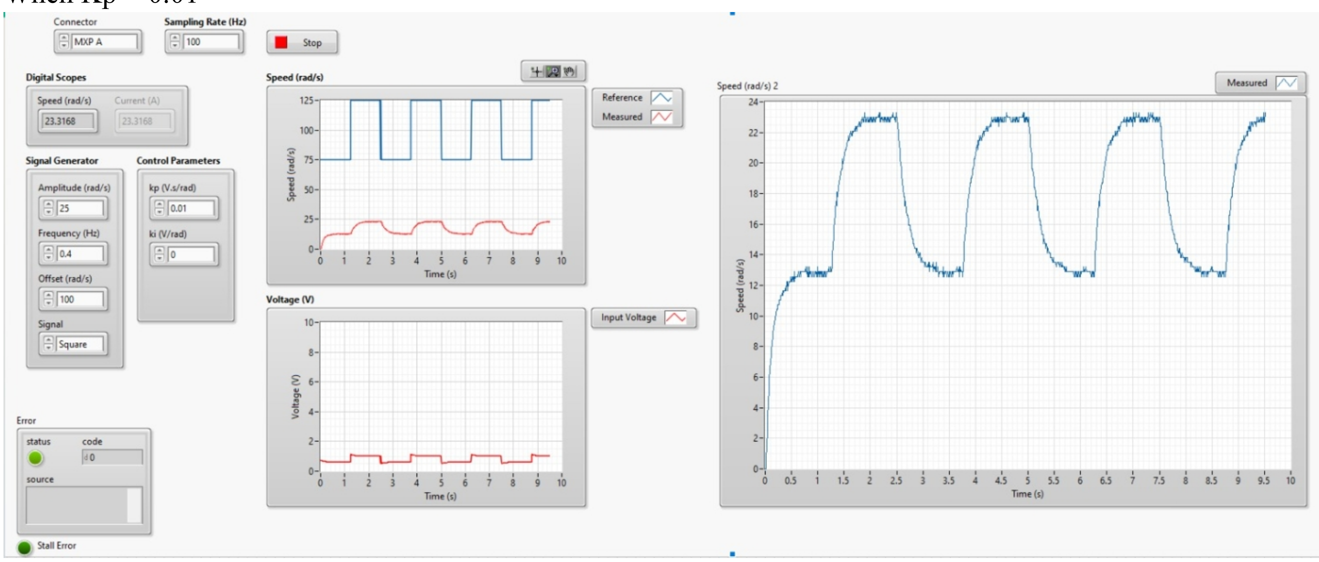
Task 3: To investigate the impact of proportional control gain and integral control gain

1. Set $K_I = 0$ in your VI. Gradually increase K_P by steps of 0.005 and look at the changes in the measured signal with respect to the reference signal and the control signal.

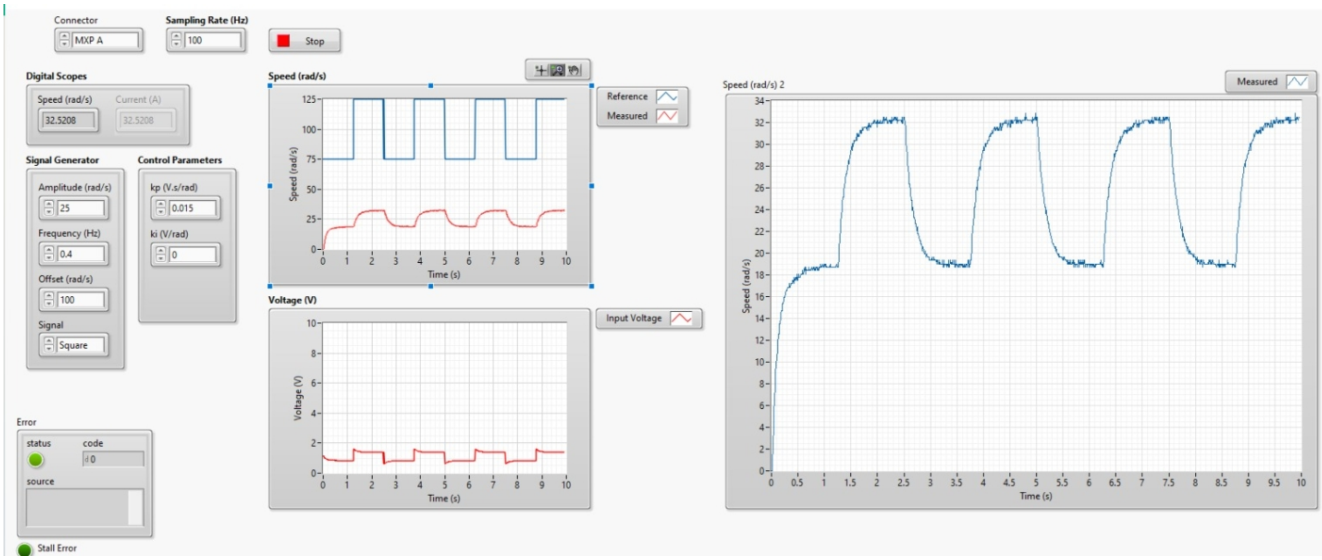
When Kp = 0.005



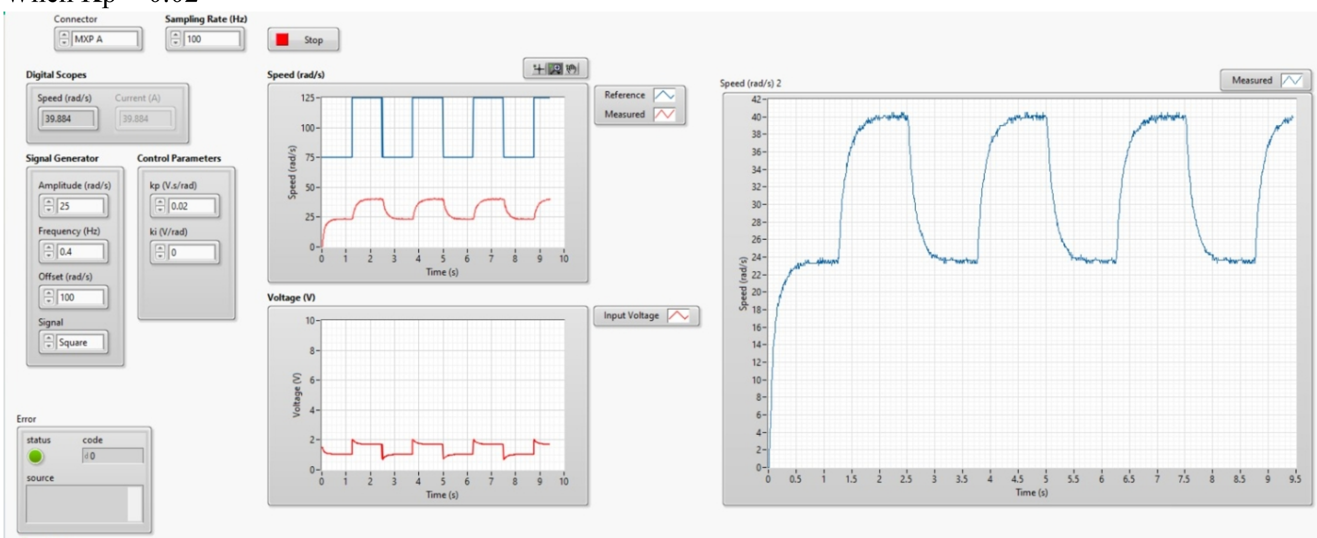
When Kp = 0.01



When Kp = 0.015



When Kp = 0.02

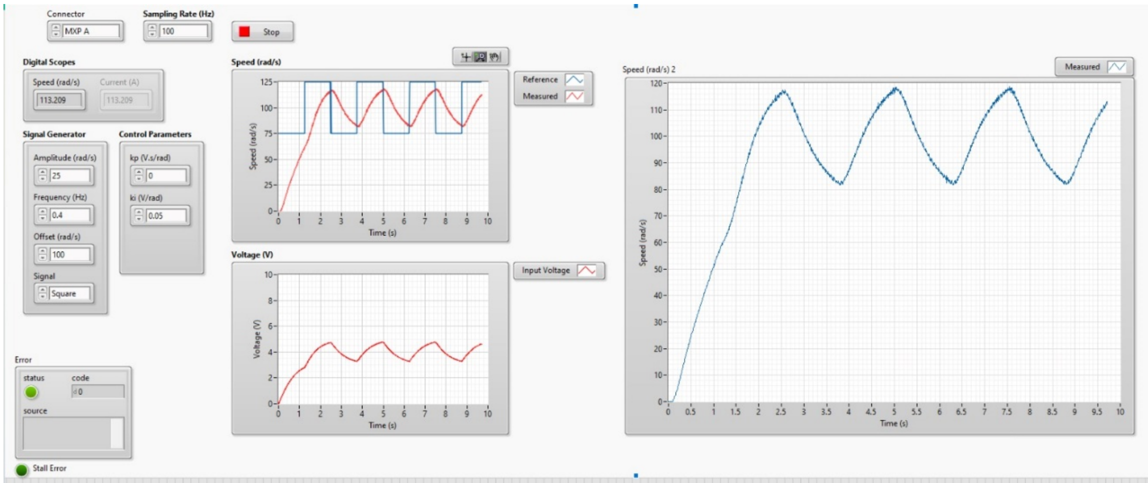


2. Explain the performance difference of changing K_P. What is the effect of increasing K_P on the steady state error and rise time of the output? Save the necessary figures.

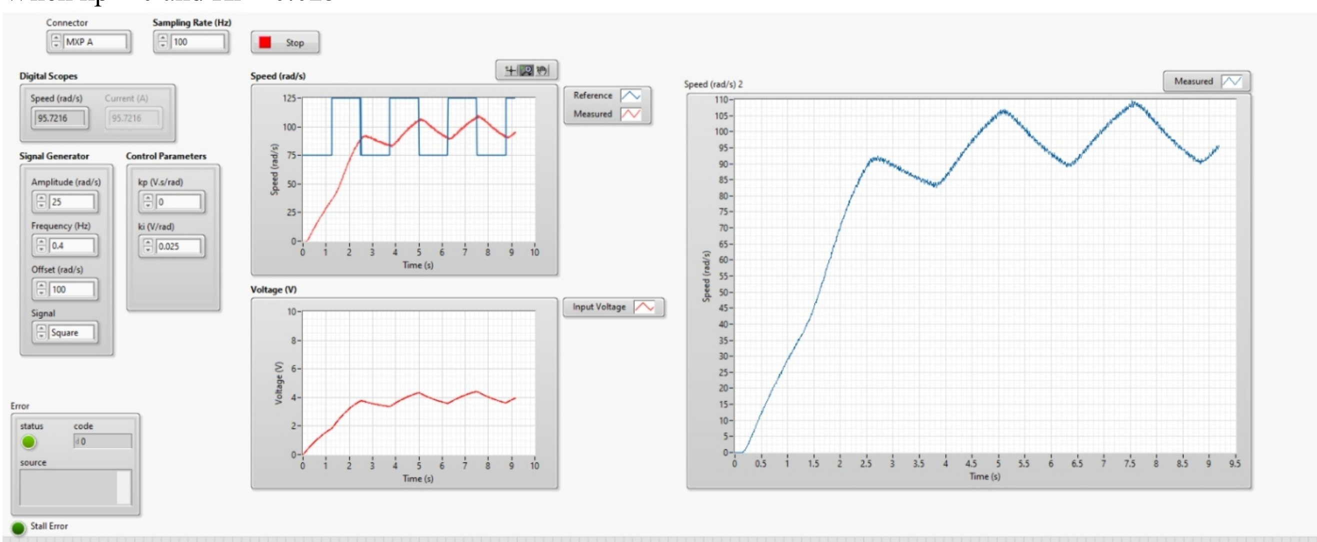
Performance difference of increasing KP: From our graphs, we can see that the steady error decreases as we increase the value of Kp. The difference between the transfer function output and the actual measured output (the error) decreases as Kp increases. The rise time increases slightly as we increase Kp. We can also see that the voltage overshoot increases noticeably as Kp increases.

3. Now, set $K_P = 0$. Gradually increase K_I by steps of 0.05 and look at the changes in the measured signal with respect to the reference signal. Explain the performance difference of changing K_I. What is the effect of increasing K_I on the output (think in terms of the steady state error, rise time, overshoot, and settling time)? Try to make sense of your observations in light of Task 1 (part 3).

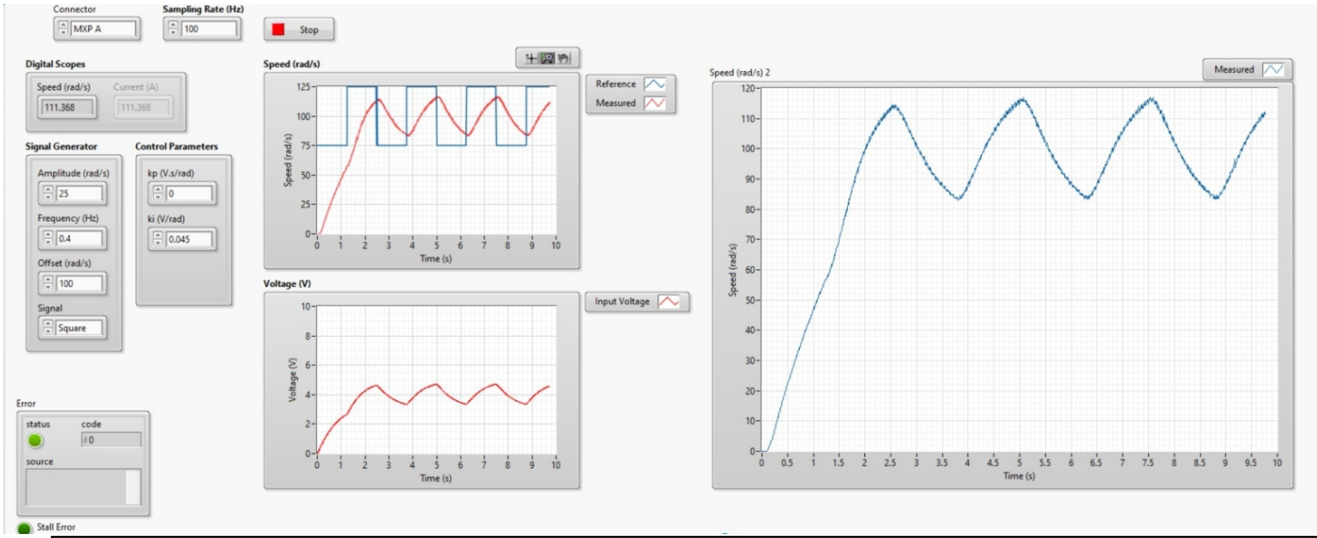
When Kp = 0 and Ki = 0.05



When kp = 0 and Ki = 0.025



When kp = 0 and Ki = 0.045



Performance difference of increasing KI: KI is responsible for eliminating steady state error. Rise time has remained unchanged. Also peak time has been increased. Furthermore, we also see an increase in the overshoot, and settling time has also been reduced to help the system converge faster to the setpoint.

Task 4: To design a PI controller based on time domain specifications

1. Using the formulae given in Lab 07, calculate the proportional and integral control gains, K_P and K_I to meet the response specifications given in Table 1. First calculate the damping ratio and natural frequency. Use K and τ from the results of grey-box modelling for calculating gains.

$$\omega_n = \sqrt{\frac{K_I K}{\tau}}$$

$$\gamma = \frac{1 + K_p K}{2\sqrt{K\tau K_I}}$$

These are the formulas used to find natural frequency and damping ratio

$K = 23.68$

$\tau = 0.2$

$t_p = \dfrac{\pi}{\omega_n \sqrt{1-\zeta^2}}$

$OS = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}} \times 100$

$= 1.1067\zeta^2$

$2.8 = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}} \times 100$ $\boxed{OS = e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}} \times 100\%}$

$-3.5755 = \dfrac{-\pi\zeta}{\sqrt{1-\zeta^2}}$

$1.138\sqrt{1-\zeta^2} = \zeta$

$1.295 - 1.295\zeta^2 = \zeta^2$

$\zeta = \sqrt{\dfrac{1.295}{1.295+1}} = 0.751$

$\Rightarrow t_p = \dfrac{\pi}{\omega_n\sqrt{1-\zeta^2}} \Rightarrow 0.3 = \dfrac{\pi}{\omega_n\sqrt{1-0.751^2}}$

$\boxed{\omega_n = 15.86}$

$\Rightarrow \omega_n = \sqrt{\dfrac{K_I K}{\tau}}$

$15.86 = \sqrt{\dfrac{K_I(23.68)}{0.2}}$

$\Rightarrow \boxed{K_I = 2.12}$

$\Rightarrow \zeta = \dfrac{1+KK_P}{2\tau} \times \sqrt{\dfrac{\tau}{K_I K}}$

$0.751 = \dfrac{1+23.68(K_P)}{2(0.2)} \times \sqrt{\dfrac{0.2}{2.12(23.68)}}$

$\boxed{K_P = 0.159}$

2. In the provided VI, set the control gains to the computed values. *Save the speed response.* Measure the peak time and percentage overshoot of the observed response to complete Table 1.

Table 1: Response time-domain specifications and corresponding controller gains

Desired Peak Time	**0.3 sec**	**Desired Percentage Overshoot**	**2.8%**
Damping Ratio	0.751	Natural Frequency	15.86
Proportional Control Gain	0.159	Integral Control Gain	2.12
Measured Peak Time	0.12	Measured Percentage Overshoot	11.56
Adjusted Proportional Control Gain	0.1	Adjusted Integral Control Gain	0.7
Adjusted Peak Time	0.3	Adjusted Percentage Overshoot	0.5%

3. Compare the obtained response with the desired one. Are the specifications satisfied? If the specifications are not satisfied, adjust the gains to meet specification. Save the resulting response. Note down the adjusted gains and measurements, and comment on how you modified your controller to arrive at those results.

All our requirements were satisfied apart form achieving an overshoot of 2.8% -we achieved an overshoot of nearly 0% with the chosen values of Ki and Kp. After adjusting the Proportional Control Gain and Integral control gain, we arrived at our desired peak time of 0.3 seconds. When we changed the values of Ki and Kp, and settled at the written adjusted values, we got overshoot equal to zero. We used the Ziegler-Nichols method to arrive at the values for Ki and Kp. We initially kept Ki =0 and started changing the value of Kp. We changed the value until the system became unstable. At this time, we used the value of Kp just before the system became unstable, and then started tweaking Ki. Changing Ki allowed us to achieve our required peak time.

8.4 DC Motor Position Control using PD Controller

The control of the position of DC motor is a good way to investigate the benefits of the PD control. It is typically used to stabilize the closed-loop system. The control signal generated by standard PD controller has the following form:

$$u(t) = K_P e(t) + K_D \frac{d}{dt} e(t)$$

In Laplace domain, it can be expressed as: $C(s) = K_P + K_D s$

Task 5: To implement the PD controller for DC motor position control

The transfer function representing the DC motor position-voltage relationship with steady-state gain K and time constant τ is $G(s) = \frac{Y(s)}{U(s)} = \frac{K}{s(\tau s + 1)}$.

1. Find the closed-loop transfer function $T(s)$ relating the position reference $R(s)$ to the output angular position $Y(s)$, when PD controller is used with the motor. Compare it with the standard second order characteristic polynomial to express K_P and K_D in terms of the damping ratio and natural frequency.

$G(s) = \frac{Y(s)}{U(s)} = \frac{K}{s(\tau s+1)}$

$T(s) = \frac{Y(s)}{R(s)} = \frac{C(s)G(s)}{1+C(s)G(s)}$

$u(t) = K_p e(t) + K_D \frac{d}{dt} e(t)$

$U(s) = K_p + K_D s$

$Y(s) = G(s)U(s) = \frac{K}{s(\tau s+1)}(K_p + K_D s)$ $\quad \therefore U(s) = C(s)$

$Y(s) = \frac{KK_p + KK_D s}{s(\tau s+1)} = G(s)C(s)$

$T(s) = \frac{(KK_p + KK_D s)/s(\tau s+1)}{1 + \frac{KK_p + KK_D s}{s(\tau s+1)}} = \frac{K(K_p + K_D s)}{s(\tau s+1) + K(K_p + K_D s)}$

→ Dividing by τ

$T(s) = \frac{(KK_p + KK_D s)/\tau}{\frac{\tau s^2 + (KK_D+1)s + KK_p}{\tau}}$ $\Rightarrow$ $\omega_n^2 = \frac{KK_p}{\tau}$

$K_p = \frac{\omega_n^2 \tau}{K}$

$= \frac{(KK_p + KK_D s)/\tau}{s^2 + \left(\frac{KK_D+1}{\tau}\right)s + \frac{KK_p}{\tau}}$ — ①

Finding K_D:

$2\zeta\omega_n = \frac{1+KK_D}{\tau}$

$\equiv s^2 + 2\zeta\omega_n s + \omega_n^2$ — ②

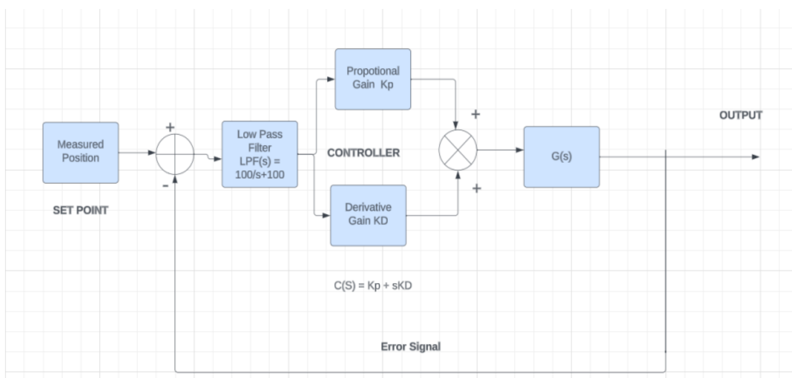
$\boxed{K_D = \frac{2\zeta\omega_n\tau - 1}{K}}$

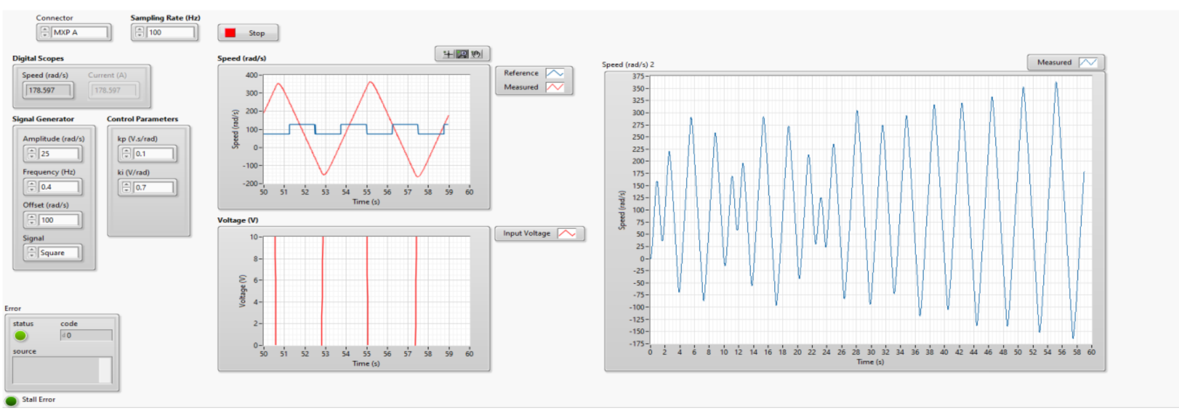
now equating ① + ②:

$s^2 = 1$

$2\zeta\omega_n = \frac{1+KK_D}{\tau}$ + $\omega_n^2 = \frac{KK_D}{\tau}$

2. Use the provided VI (Position Control.vi) where DC motor position control is implemented with PD controller. It may not be a good idea to implement the ideal PD controller as it is. The reason being that measured signals are almost always noisy. Differentiating a noisy measured signal will result in large fluctuations in the control signal. To tackle this situation, a low-pass filter is used in the path of the error signal which is being differentiated for PD controller. The low pass filter $LPF(s) = \frac{100}{s+100}$ can be used before or after computing the derivative. Through block diagram representation, represent the implemented VI.



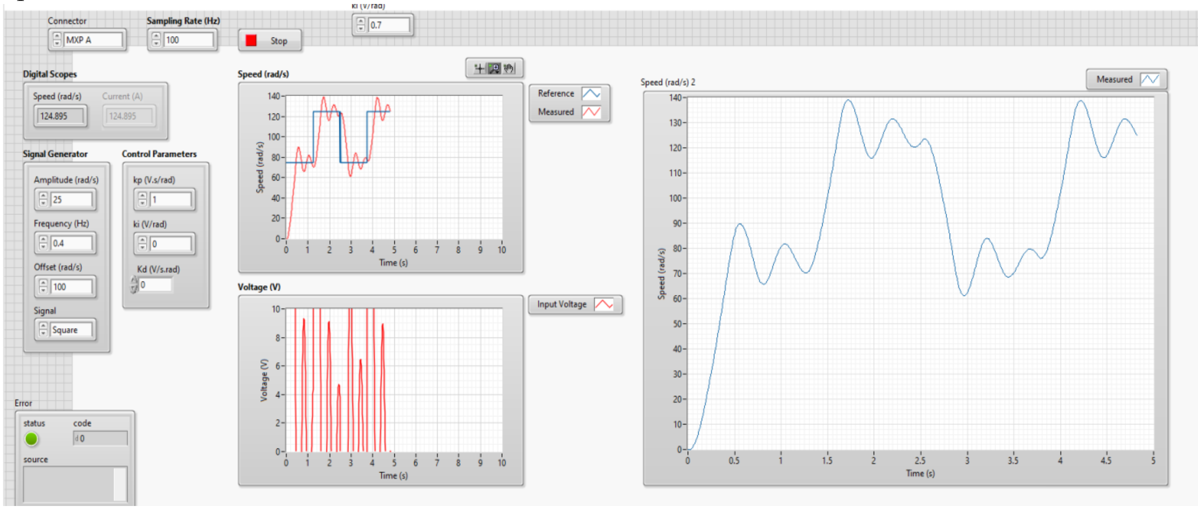


After running we are getting above output

Task 6: To investigate the impact of proportional control gain and derivative control gain for DC Motor position control

1. Set $K_D = 0$ in the VI. Vary K_P between 1 and 4 and look at the changes in the measured signal with respect to the reference signal. What is the effect of increasing K_P on the system's performance (think in terms of the steady state error, rise time, overshoot, and settling time)? Justify. *Save the necessary figures.*

Kp=1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Stop
Digital Scopes
Speed (rad/s)
Current (A)
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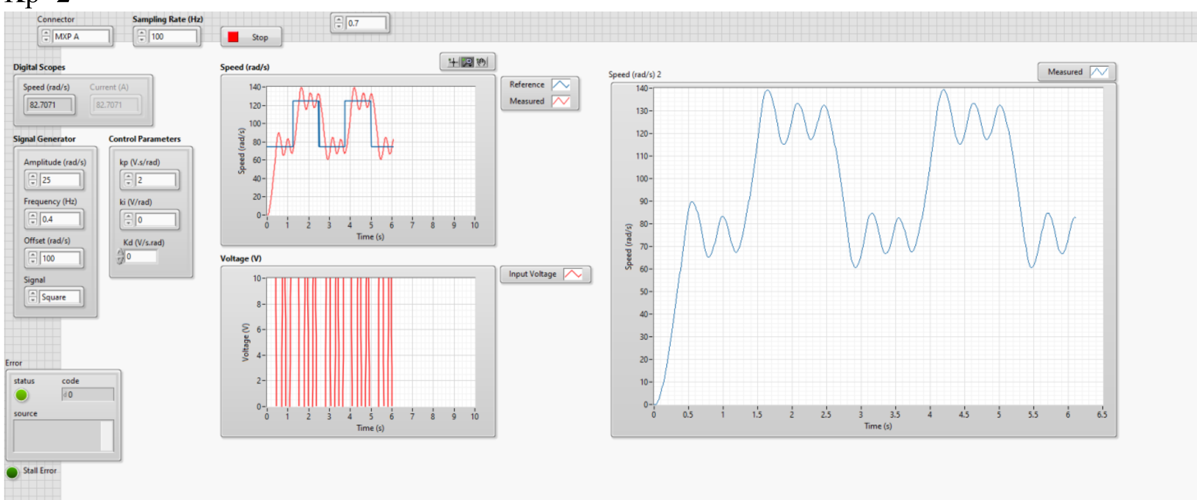
Signal Generator
Amplitude (rad/s)
Frequency (Hz)
Offset (rad/s)
Signal
Square
Control Parameters
kp (V.s/rad)
ki (V/rad)
Kd (V/s.rad)
Error
status
code
source
Speed (rad/s)
Reference
Measured
Time (s)
Voltage (V)
Input Voltage
Speed (rad/s) 2
Measured

Kp=2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Digital Scopes
Speed (rad/s)
Current (A)
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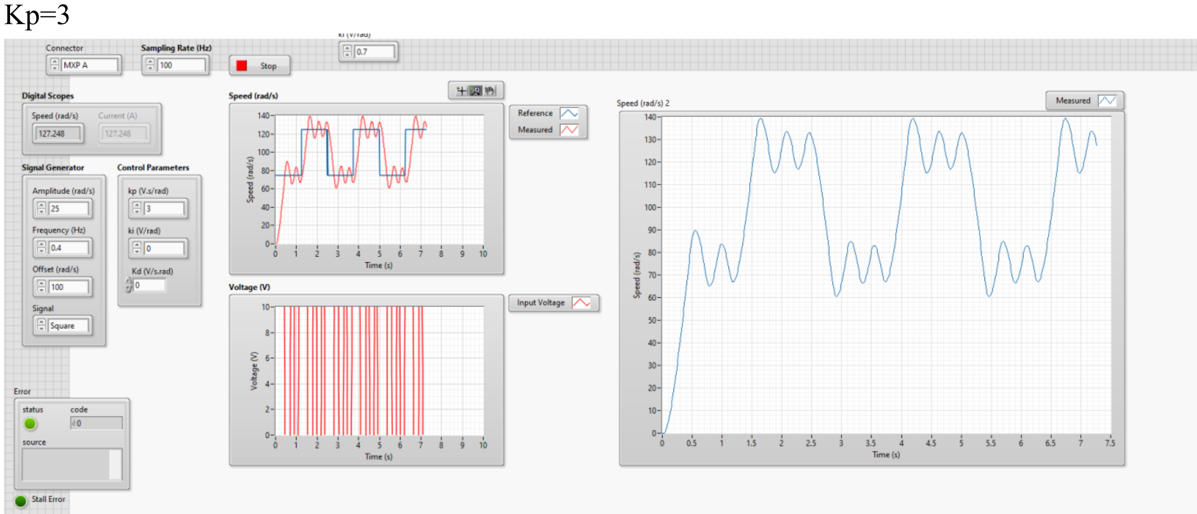
Signal Generator
Amplitude (rad/s)
Frequency (Hz)
Offset (rad/s)
Signal
Square
Control Parameters
kp (V.s/rad)
ki (V/rad)
Kd (V/s.rad)
Error
status
code
source
Stall Error
Speed (rad/s)
Reference
Measured
Time (s)
Voltage (V)
Input Voltage
Speed (rad/s) 2
Measured

Kp=3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Stop
Digital Scopes
Speed (rad/s)
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Signal Generator
Amplitude (rad/s)
Frequency (Hz)
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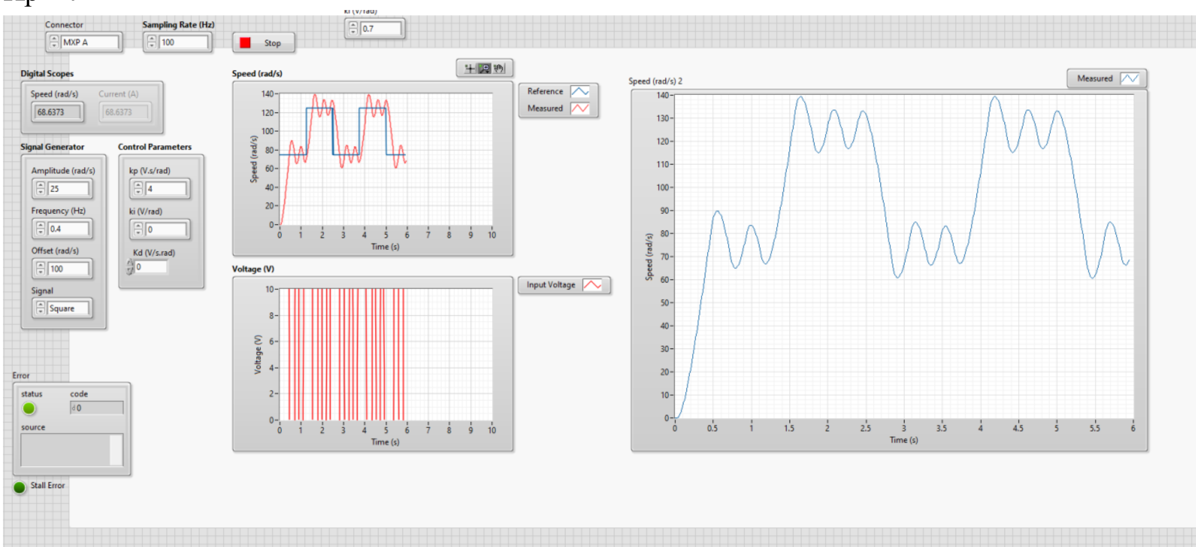
Square
Control Parameters
kp (V.s/rad)
ki (V/rad)
Kd (V/s.rad)
Error
status
code
source
Stall Error
Speed (rad/s)
Reference
Measured
Time (s)
Voltage (V)
Input Voltage
Speed (rad/s) 2
Measured

Kp =4



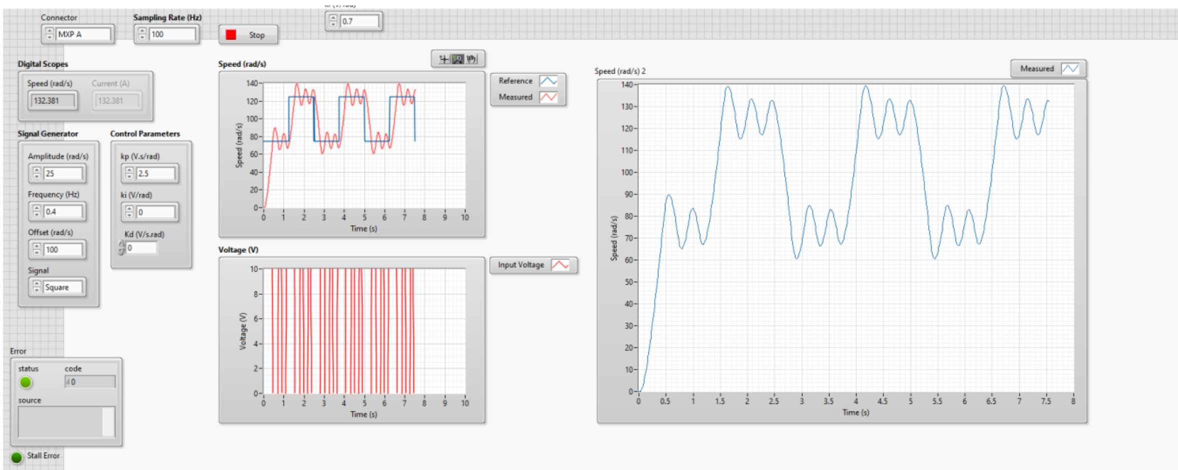
When Kp was increased from 1 to 4, the rise time decreases a bit, provided that kd = 0. Since according to the formula of rise time it is inversely proportional to natural frequency and square root of kp is directly proportional to natural frequency, so when kp increases, wn increases which in turn decreases the rise time.

The overshoot is almost remain same. We know that according to the equation found out damping ratio is Inversely proportional to square root of kp, so when kp increases, damping ratio decrease. And we know that according to formula of overshoot, damping ratio is in its numerator and denominator, so little decrease in damping ratio has no significant impact on overshoot

Since, according to our observation, steady state haven't been reached so settling time is same for all variations done above. Also, there is no significant reduction in steady state error.

2. Set $K_P = 2.5$ in the VI. Gradually increment K_D from 0 to 0.15 and look at the changes in the measured signal with respect to the reference signal. What is the effect of increasing K_D on the output (think in terms of the steady state error, rise time, overshoot, and settling time)?

Kd = 0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Stop
0.7
Digital Scopes
Speed (rad/s)
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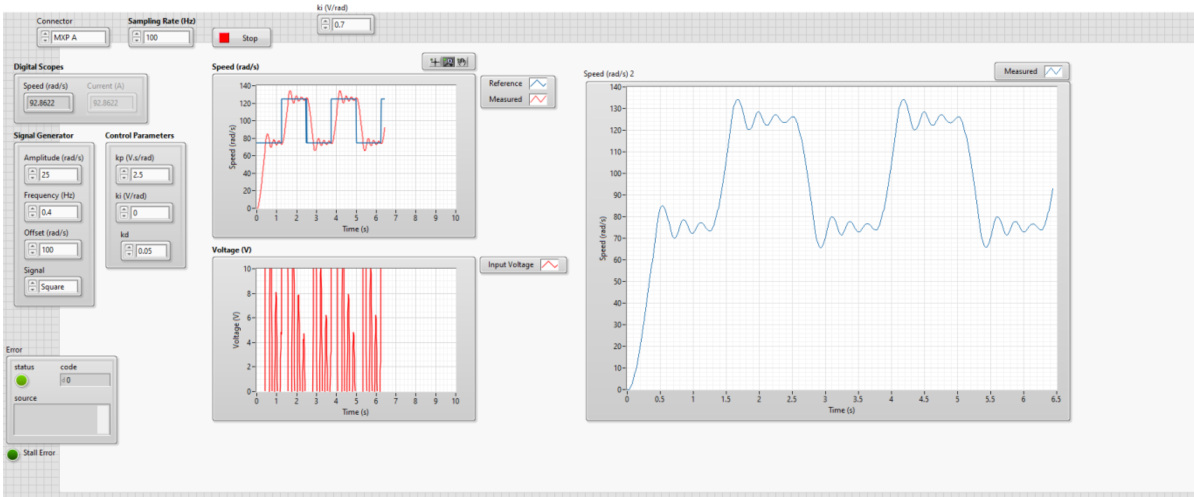
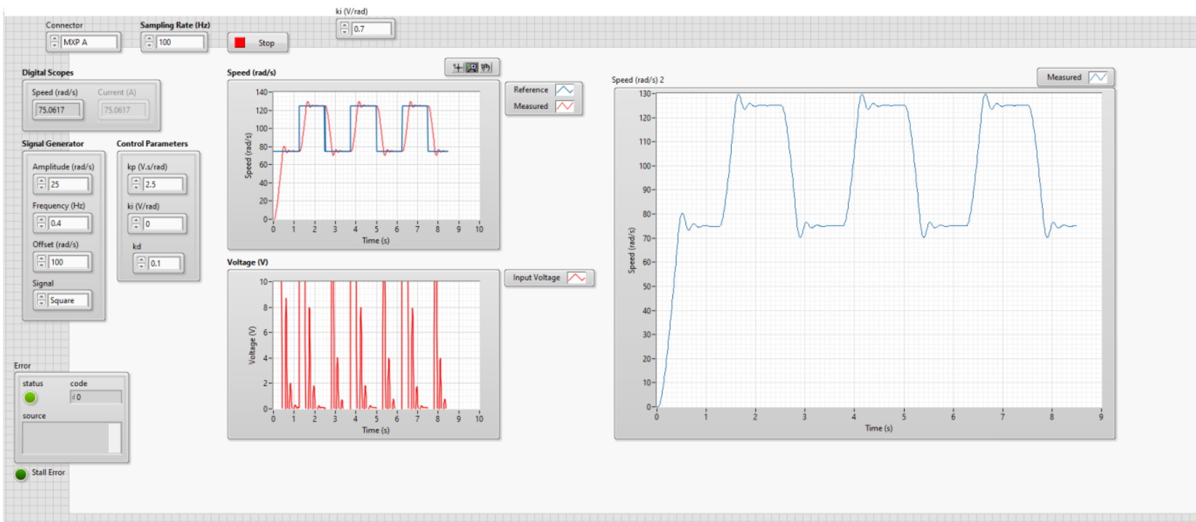
Current (A)
Signal Generator
Amplitude (rad/s)
25
Frequency (Hz)
0.4
Offset (rad/s)
100
Signal
Square
Control Parameters
kp (V.s/rad)
2.5
ki (V/rad)
0
Kd (V/s.rad)
0
Speed (rad/s)
Reference
Measured
Time (s)
Voltage (V)
Input Voltage
Speed (rad/s) 2
Measured
Error
status
code
source
Stall Error

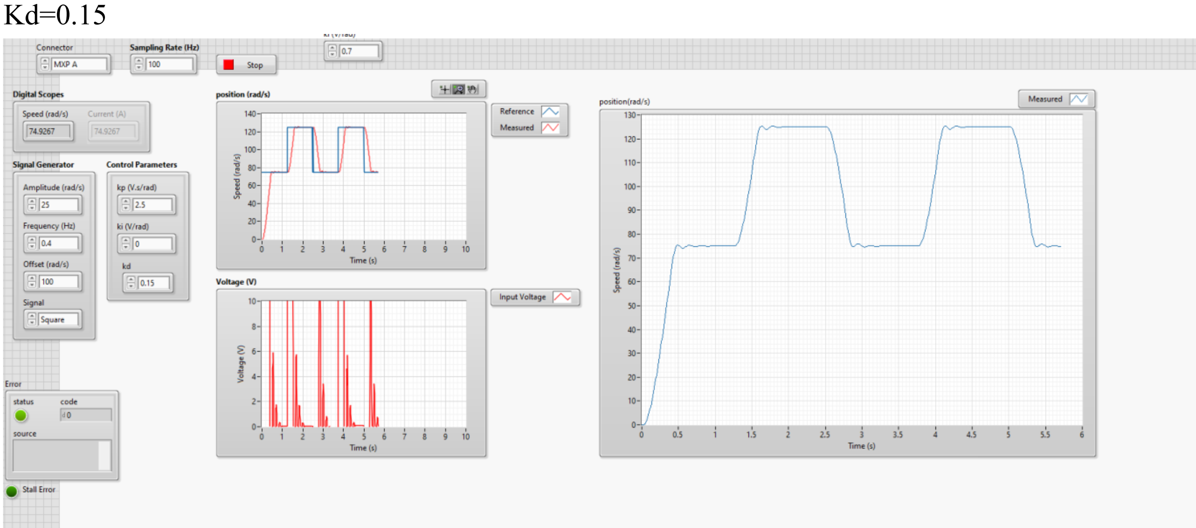
Kd = 0.05



Kd = 0.1



Kd=0.15



When Kd was increased from 0 to 0.15, the rise time decreases a bit, provided that kp is fixed at 2,5. The damping ratio will increase when the Kd will increase as per the formula found above, And we know that that in formula of rise time damping ratio is in its denominator so, when damping ratio will increase, it will decrease the rise time. Ofcourse the decrease will be very small due to kp being fixed having its affect as well.

The overshoot is almost remain same. And we know that according to formula of overshoot, damping ratio is in its numerator and denominator, so little increase in damping ratio has no significant impact on overshoot however, it might decrease just a little bit

Since, according to our observation, the settling time will increase as there will be increase in kd value as can be seen from above graph. Also, there is also reduction in steady state error as kd increases.

3. Find the steady-state error expression for DC motor position control using PD controller. Does the result verify your observations of the measured response?

$$\therefore E(s) = \frac{R(s)}{1 + C(s)G(s)}$$

$$G(s) = \frac{K}{s(Ts+1)}, \quad C(s) = K_p + K_d s$$

$$E(s) = \frac{R(s)}{1 + \left(\frac{K}{s(Ts+1)}\right)(K_p + K_d s)}$$

$$E(s) = \frac{R(s)[s(Ts+1)]}{s(Ts+1) + KK_p + KK_d s}$$

Applying final value theorem

$$E(s) = \lim_{s \to 0} s \frac{s^2 T R(s) + s R(s)}{s^2 T + s + KK_p + KK_d s}$$

If $R(s) = 1/s$ (step response)

we will get

$$E(s) = \frac{1}{KK_p}$$

So, as there is increase in Kp the steady state error will decrease, which does verify our observation

Task 7: To design the PD controller based on time-domain response specifications

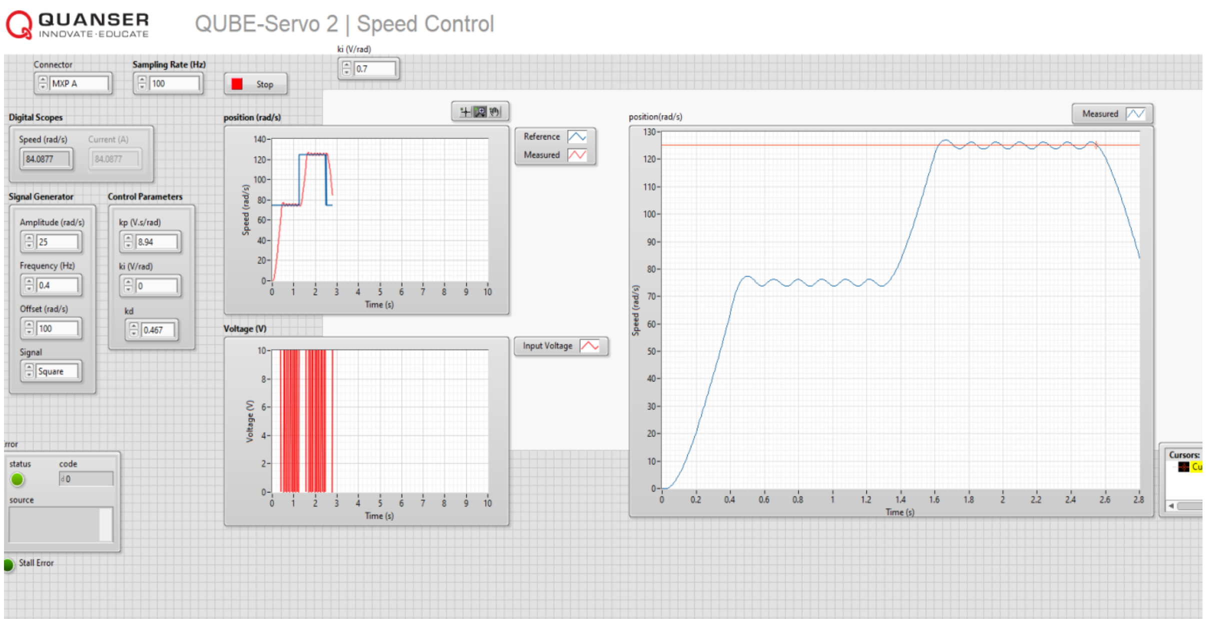
1. Calculate the proportional and derivative control gains, K_P and K_D respectively, for the response to have a peak time of 0.15s and a percentage overshoot of 2.5%. Fill in table 2.

Table 2: Response time domain specifications and corresponding controller gains

Desired Peak Time	**0.15s**	**Desired Percentage Overshoot**	**2.5 %**
Damping Ratio	0.761	Natural Frequency	32.31

Proportional Control Gain	7.94	Derivative Control Gain	0.33
Measured Peak Time	0.374	Measured Percentage Overshoot	3.12%
Adjusted Proportional Control Gain	9,94	Adjusted Derivative Control Gain	0.467
Adjusted Peak Time	0.343	Adjusted Overshoot	1.4%

2. Compare with the specified values. Are the specifications satisfied? If the specifications are not satisfied, adjust the gains to meet specification. Attach the resulting response, measurements, and comment on how you modified your controller to arrive at those results.



The specifications are unsatisfied
When we tried to adjust values, after countless tries we were unable to reach to close to values of desired peak time and natural frequency. We got our final peak time as 0.343 and natural frequency as 1.4%
We vary kp and kd accordingly as per our observation from formulas

Task 8: Post-Lab Task

1. How does an integral control compare to a proportional control?
2. What is the benefit of using proportional-integral control over integral control only?
3. Why does the steady-state error go to zero for position control of DC motor with PD controller when there is no integral part in the controller?
4. If you just use the derivative controller for position control system, will the steady-state error go to zero? Justify.

1. Proportional control (P) is a simple control scheme that adjusts the output of a system in proportion to the error between the desired and actual output. Integral control (I) is a more complex control scheme that takes into account the accumulated error over time.
Integral control has several advantages over proportional control:

- Integral control can eliminate steady-state error, which is the error that remains in the system even after the system has reached a steady state.
- Integral control can improve the response time of the system, which is the time it takes for the system to reach a steady state after a change in the input.
- Integral control can reduce the overshoot of the system, which is the amount by which the system output exceeds the desired output before settling down.

2. The main benefit of using proportional-integral (PI) control over integral control only is that PI control can improve the response time of the system. PI control does this by using the proportional term to respond to the current error and the integral term to respond to the accumulated error over time.
   The proportional term is proportional to the current error, so it will cause the controller output to change in proportion to the error. This means that the controller will respond quickly to changes in the error. The integral term is proportional to the accumulated error over time, so it will cause the controller output to change in proportion to the total error that has accumulated over time. This means that the controller will continue to adjust the output until the error is eliminated.
   By combining the proportional and integral terms, PI control can achieve both fast response time and zero steady-state error.

3. The PD controller can eliminate steady-state error in position control of a DC motor because the derivative term responds to the rate of change of the error. When the system is approaching the desired position, the rate of change of the error will decrease and the derivative term will become smaller. This will cause the controller output to decrease and the system will eventually reach the desired position.

4. The steady-state error will not go to zero if you just use the derivative controller for a position control system. This is because the derivative controller only responds to the rate of change of the error, not the magnitude of the error. Therefore, the derivative controller cannot eliminate steady-state error. there are some applications where it may be desirable to use a derivative controller only. For example, if the system is very unstable, a derivative controller can be used to damp the system and improve its stability.

Assessment Rubric
Lab 08
Proportional-Integral & Proportional-Derivative Controllers for Motor Speed and Position Control

Name: Afsah Hyder	**Student ID: 07065**

Points Distribution

Task No.	LR2 Simulation	LR4 Data Collection	LR5 Results /	LR 6 Calculations	LR 10 Analysis	AR 6 Class Participation

	/Code		Figures			
Task 1	-	-	-	-	8	-
Task 2	4	-	-	-	-	-
Task 3	-	-	8	-	8	-
Task 4	-	8	-	8	4	-
Task 5	-	-	4	-	4	-
Task 6	-	-	8	-	8	-
Task 7	-	8	-	8	4	-
Task 8	-	-	-	-	8	-
SEL	-	-	-	-	-	/20
Course Learning Outcomes	CLO 3					CLO 4
Total Points	/100					/20
	/120					

For details on rubrics, please refer to *Lab Evaluation Assessment Rubrics*.