ECE311F -2021
Lab1

Prepared by:
Litao Zhou(1006013092)
Jiayi Zhou(1005814031)
Shaoyang Zhang(1005751660)
Course: ECE311F 2021
Due: Oct,6,2021 8PM EST

Output 1

• **Print out the transfer functions G_motor and G_motor_simplified.**

The transfer function for G_motor:

```
>> G_motor

G_motor =

          833.3
  ---------------------
  s^2 + 150.2 s + 33.33
```

The transfer function for G_motor_simplified:

```
>> G_motor_simplified

G_motor_simplified =

    5.556
  ----------
  s + 0.2222
```

• **Print out the transfer function in zpk form, zpk_motor.**

The transfer function in zpk form

```
>> zpk_motor

zpk_motor =

         833.33
  -------------------
  (s+0.2223) (s+149.9)
```

• **Print out the poles of the transfer function G_motor. Comment on the location of the two poles, and how are they related to one another: are they close to each other? Is one much smaller in magnitude than the other? Comment on how you expect the motor to behave based on the location of the poles when the input voltage is a unit step.**

Based on the printed transfer function of the zpk form in the previous part, the poles of the G_motor are at s = -0.2223 and s = -149.9, and they are far away from each other. Since they only have a real part(negative) and no imaginary domain, the magnitudes of the pole is 0.2223 and 149.9. After a certain period of time, the pole at -0.2223 will have less effect on the overall performance, as it approaches zero. The pole at -149.9 will dominate the performance of the motor. Eventually, it will converge to a constant value.

• Print out the numerator and denominator arrays of the transfer functions G_motor and G_motor_simplified. You will need these arrays in Sections 5 and 6.

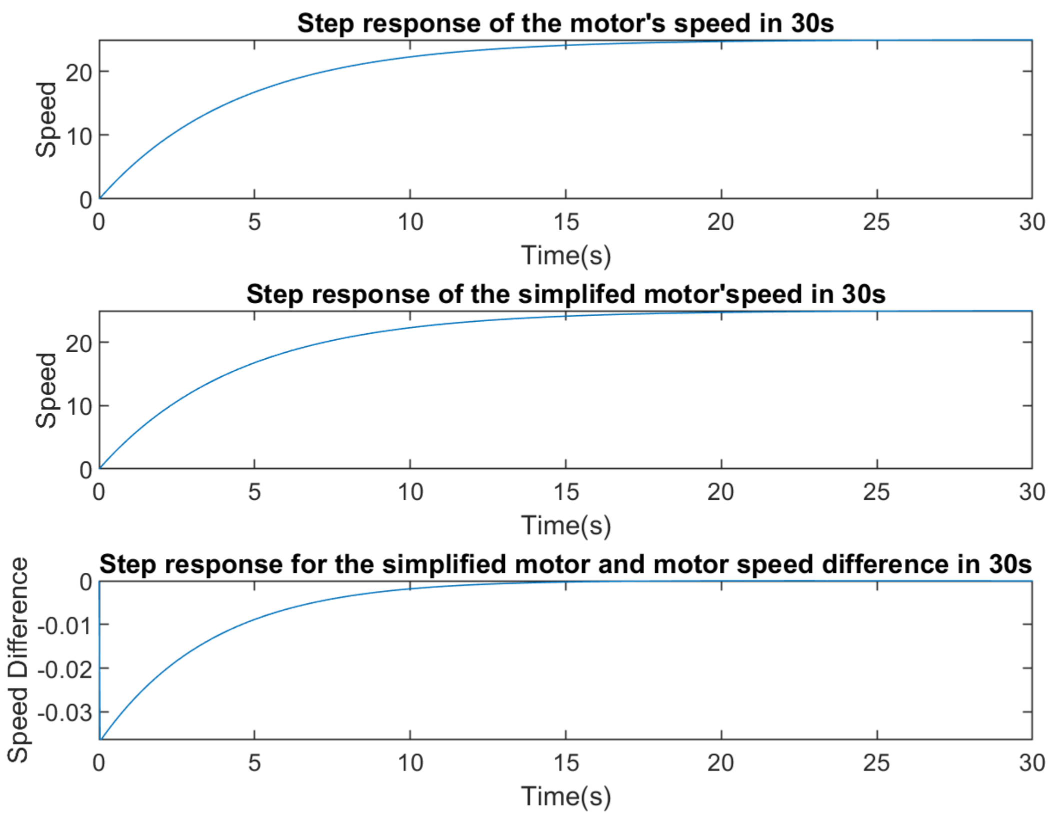
The numerator arrays of G_motor is [0, 0, 833.3333]
and the denominator arrays of G_motor is [1.0000, 150.1667,   33.3333]

The numerator arrays of G_motor_simplifiedis [0, 5.5556]
and the denominator arrays of G_motor_simplifiedis [1.0000, 0.2222]

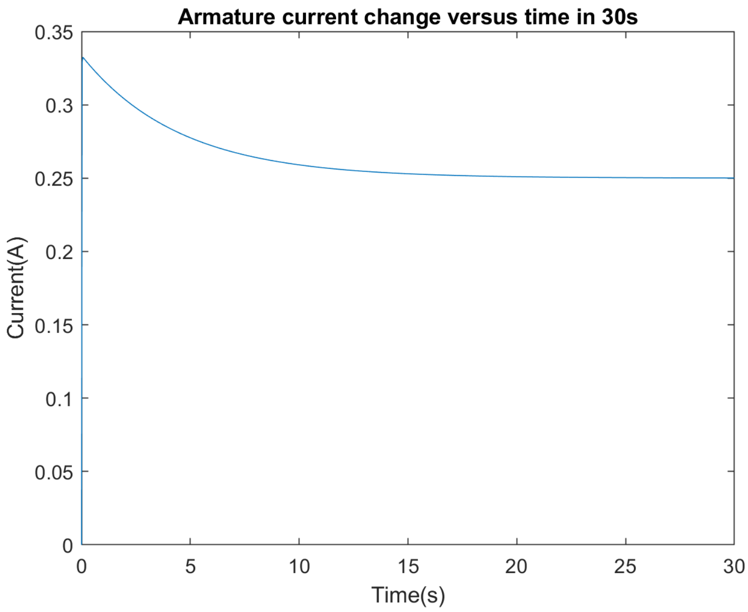
Output 2

• Produce three figures as explained above. Label the axes of each (sub-) figure, and add
titles explaining what the (sub-) figure represents.

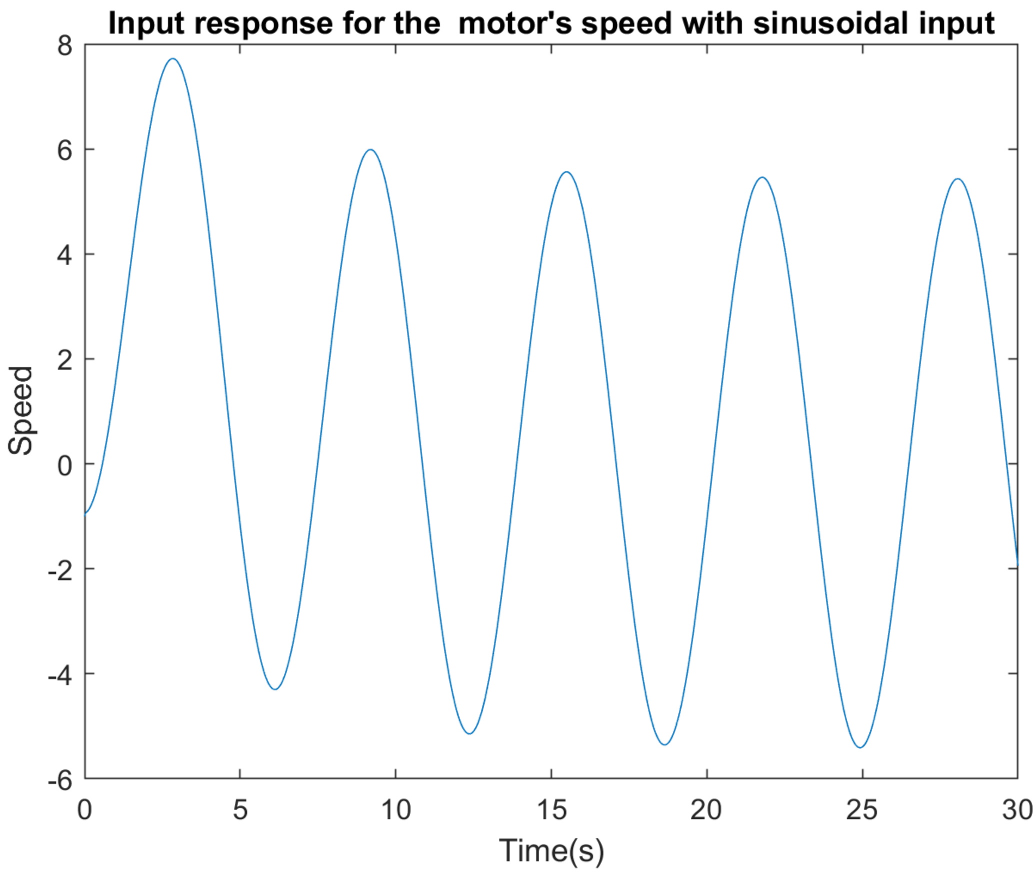
The first figure below is the graph with 3 subplots which represents the step responses(speed) of the motor, the simplified motor and the difference between two motors



The second figure below is the step response of armature current change in the system



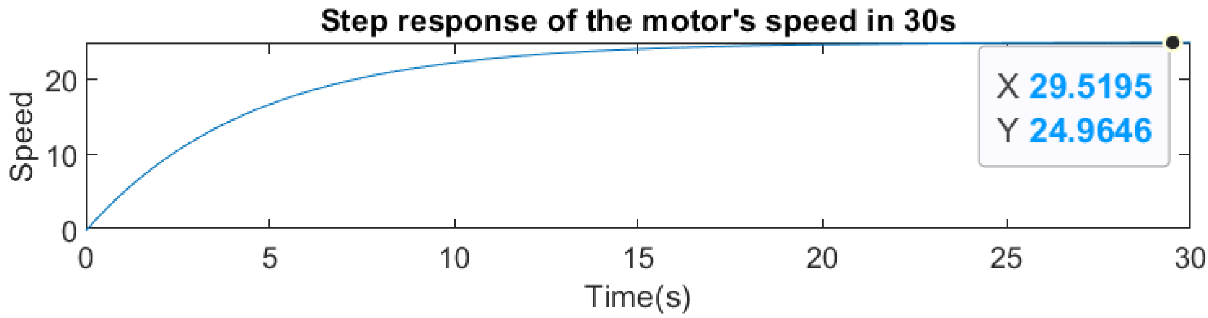
The third figure below is the step response for the motor with a initial condition and input in sine function



•Compare the step responses of the motor model and its simplified version. How close are they to each other? What is the maximum error between the two?

These two graphs are really close two graphs based on the first figure's third subplot in the previous part. For the two function models, they had the maximum error at the start of the simulation with the error value of 0.004 and the value decreased to close to zero with both function goes to steady state

• **Print the approximate asymptotic value of the motor speed in response to a unit step.**
Based on the cursor of the matlab(as shown below), the approximate asymptotic value of the motor speed is about 24.96



• **Print the theoretical asymptotic value of the motor speed in response to a unit step. Verify that the approximate value above is indeed very close to the theoretical value. Using final value theorem and the step response input as shown below:**

Final value theorm

$$\lim_{(t \to \infty)} f(t) = \lim_{s \to 0} s \cdot F(s)$$

where $F(s) = \mathcal{L}\{f(t)\}$

$$F(s) = G\_motor \cdot \frac{1}{s}$$ input (step function in laplace form)

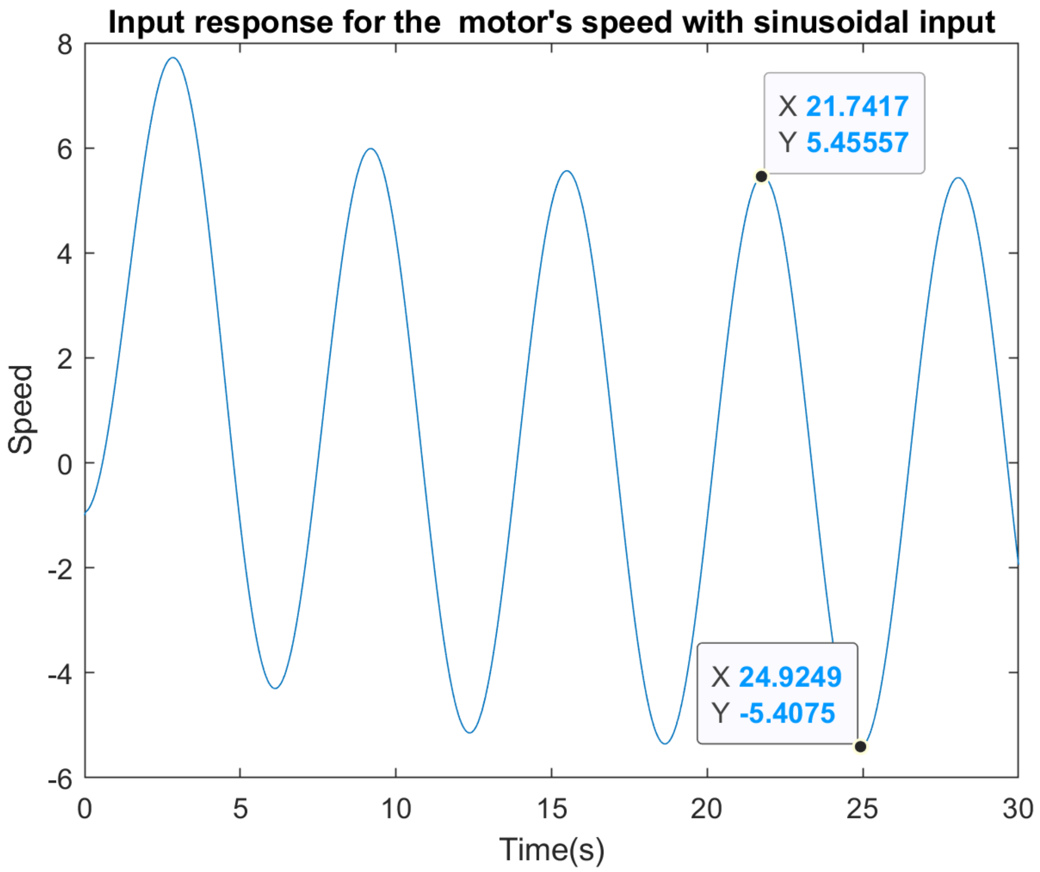
$$= \frac{833.3}{s^2+150.2s+33.3} \cdot \frac{1}{s}$$

$$\lim_{s \to 0} s \cdot F(s) = \frac{833.3}{33.3}$$

$$= 25.00$$

According to the hand writing above, the theoretical asymptotic value(25) is very close to the approximate value in the previous part(24.96),which verified the statement in the question.

• Print the approximate amplitude of oscillation of the motor speed in response to a sinusoidal input.
In this question, I will use the cursor feature to the third plot of the first figure to approximate the amplitude.



Based on the cursor, the amplitude of the graph is approximate to be (5.45557+5.4075)/2 =5.431535

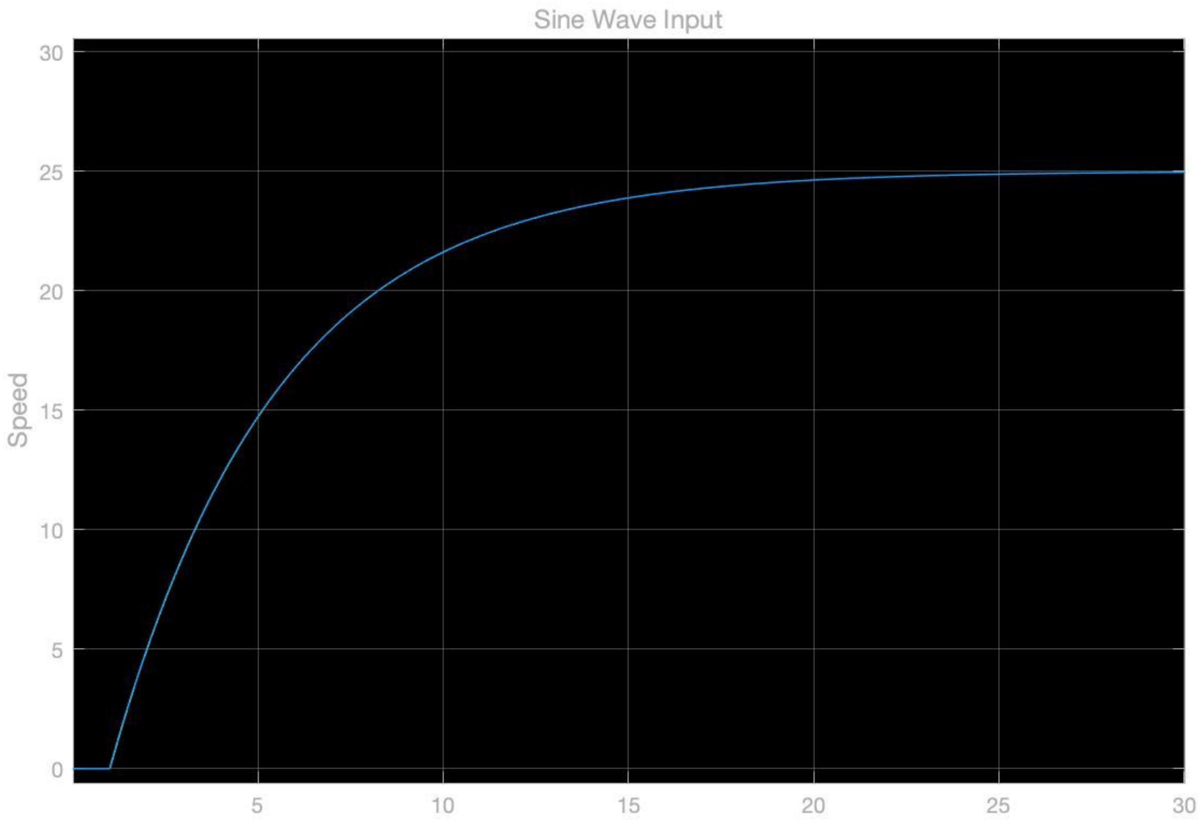
• Print the theoretical amplitude of oscillation of the motor speed in response to a sinusoidal input, and compare it to the approximate value above.

Based on the result of the evalfr(G_motor,i), the resulting is 1.1419 - 5.3035i , and the theoretical amplitude is calculated to be 5.4250, which is very close to the approximate value we calculated in the previous output.

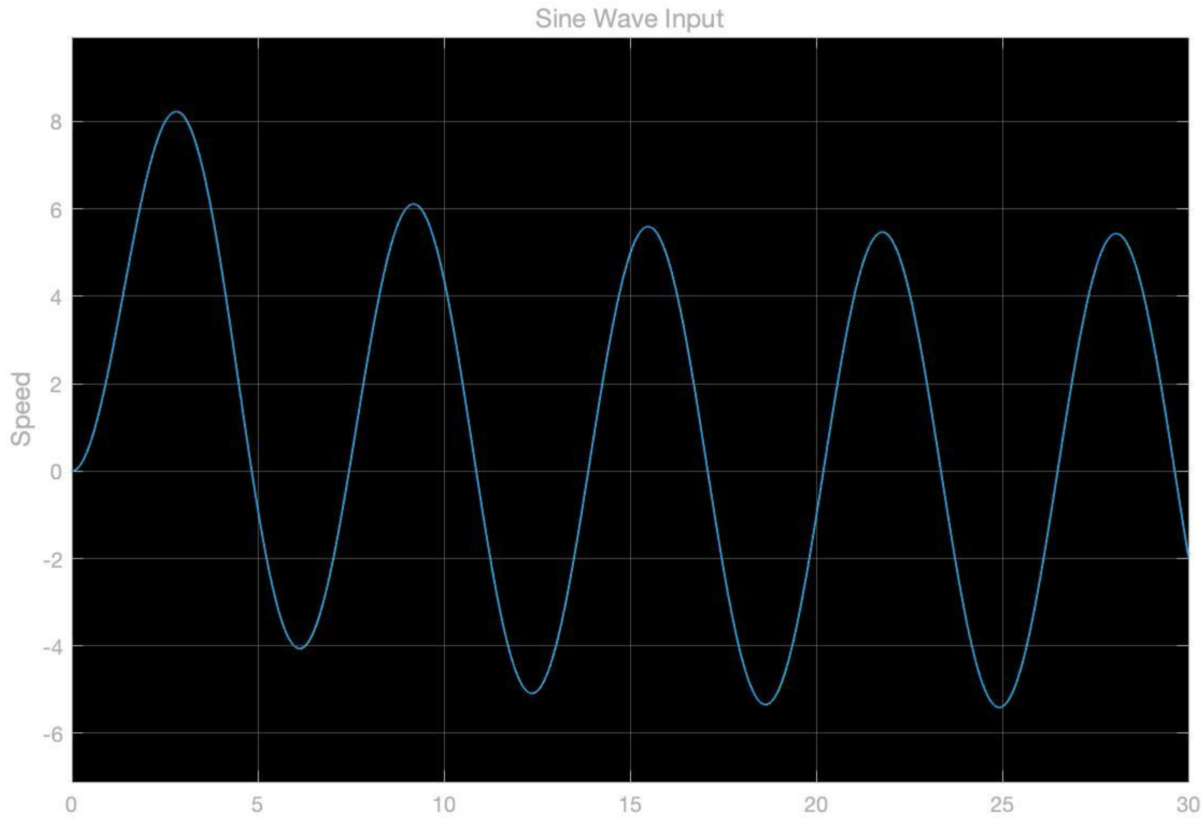
Output 3

• Produce two figures, which the output of the motor models when the input is a unit step or a sine wave

Below is the output of the motor models when the input is a unit step:



Below is the output of the motor models when the input is a sine wave:



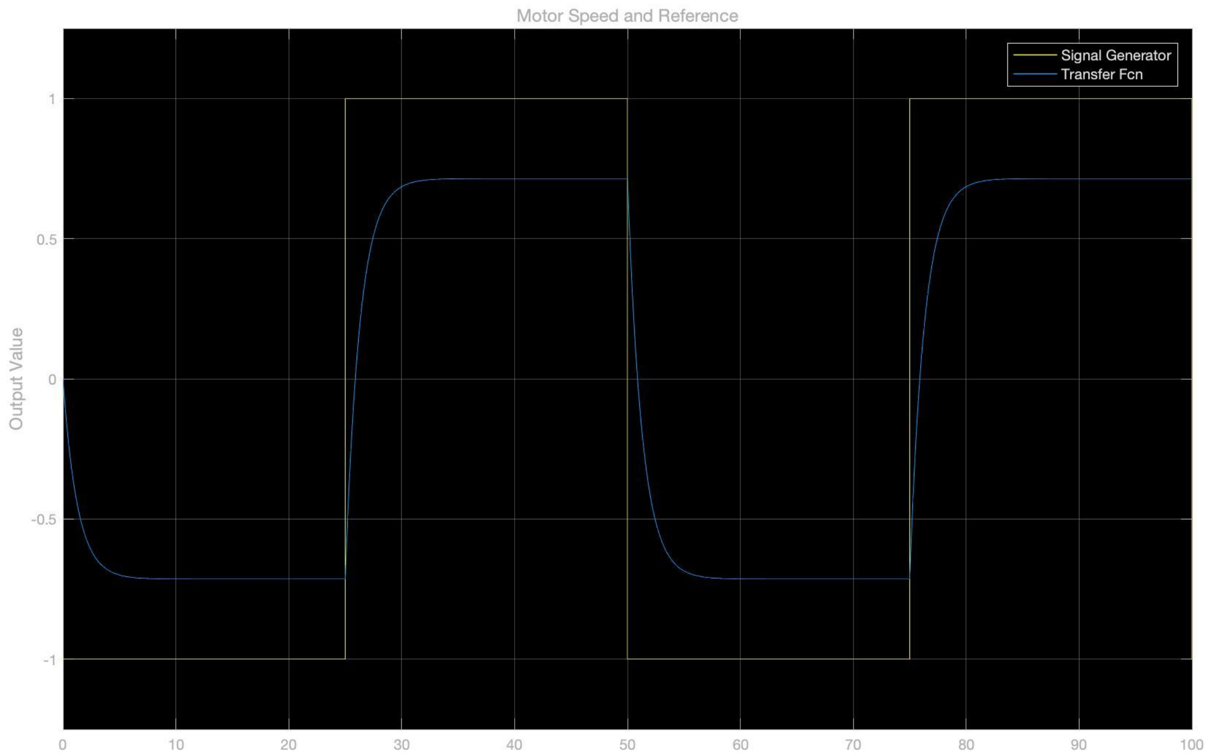
•Comment on how well the simplified transfer function model approximates the full transfer function model for the two given input signals.

We used cursor measurement to measure the speed at time 25s and 29s for unit step input and sine wave input respectively, both values matching the full DC model. So we can say that the simplified model approximates the full model well.

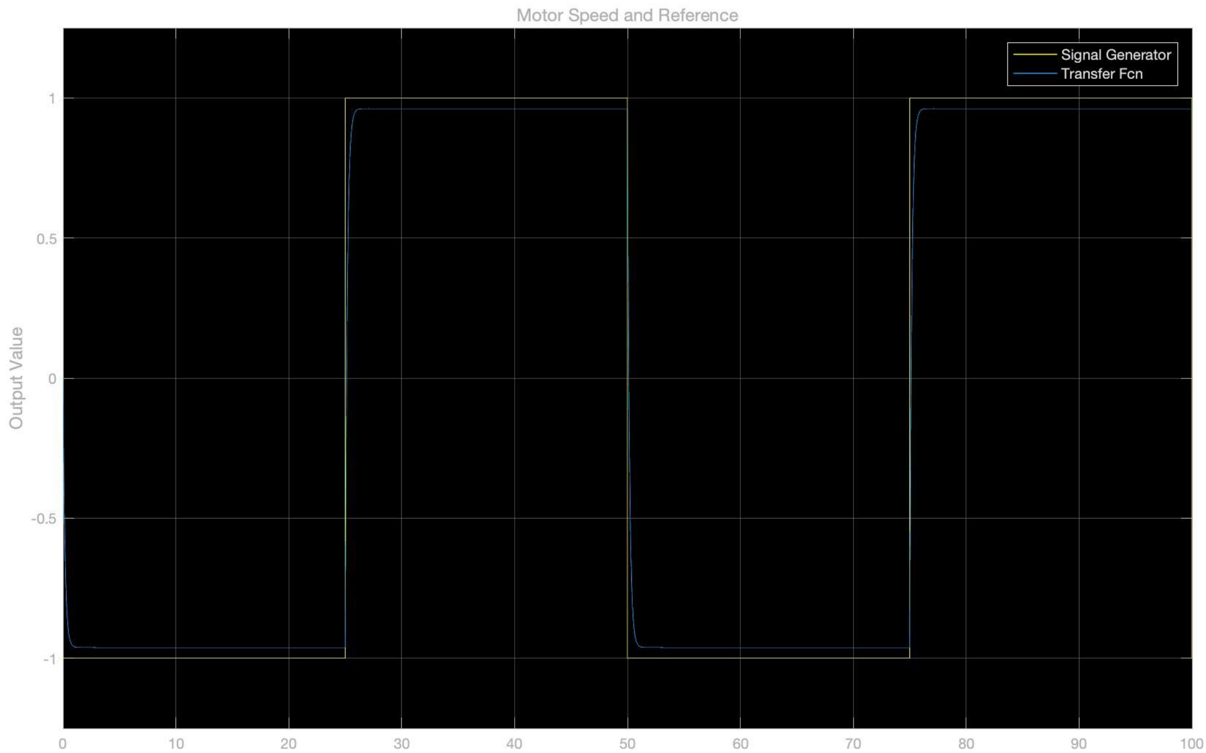
Output 4

• Produce two figures displaying the motor speed and the reference signal for the two cases of K = 0.1 and K = 1.

Below is a figure of the motor speed and the reference signal for K=0.1

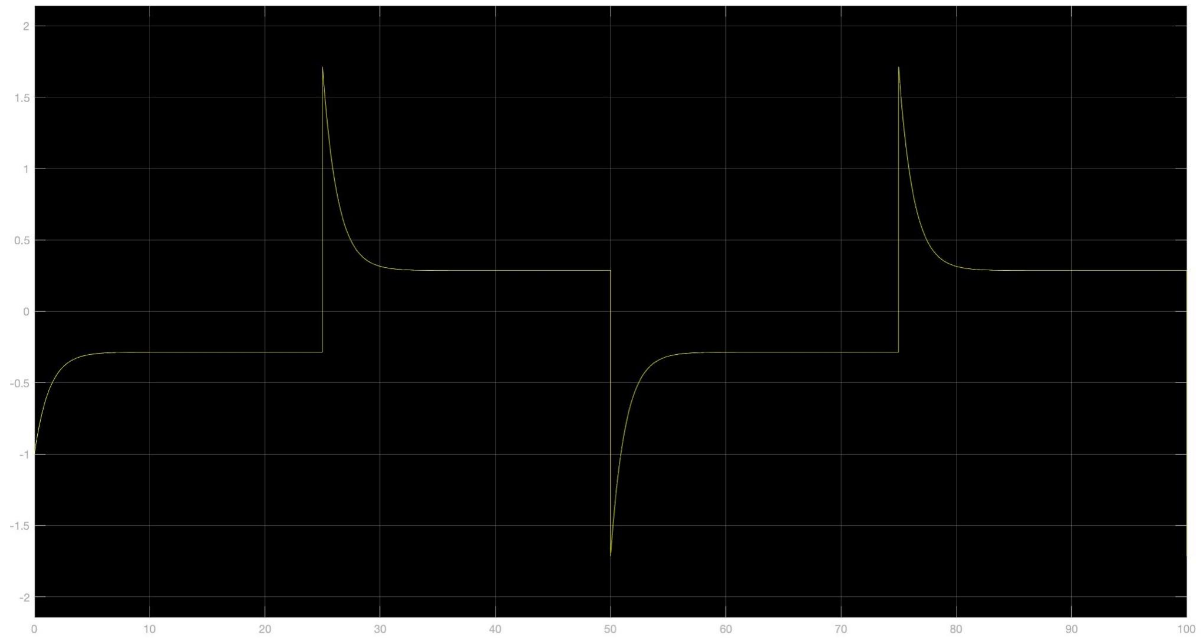


Below is a figure of the motor speed and the reference signal for K=1



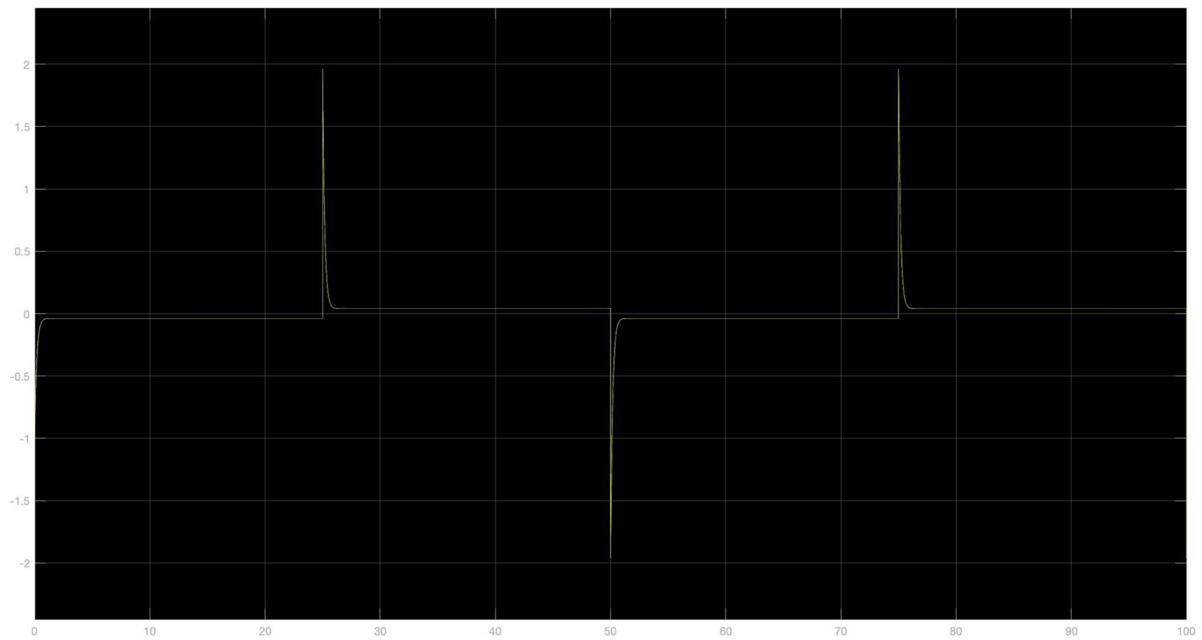
• Compare the results in the two figures, and comment on your findings. You should notice that the motor speed does not converge to the reference signal, but it gets close to it. Determine the approximate asymptotic value of the tracking error in the two cases K = 0.1 and K = 1. How is this value affected by increasing the control gain K? What about the rate of convergence, do you note differences in the rate of convergence of the tracking error to its asymptotic value as K is increase

Below is the asymptotic value of the tracking error when K=0.1



from the cursor measurements, we obtained the absolute value of the asymptotic value of tracking error = 0.2857

Below is the asymptotic value of the tracing error when K=1



from the cursor measurements, we obtained the absolute value of the asymptotic value of tracking error = 0.03846

According to the two figures above, when we increase the control gain K from 0.1 to 1, the absolute value of tracking error decreases and the transfer functions behave more like the actual input signal, in other words, the rate of convergence increases.

• Make concluding remarks. Do you think that proportional control is an adequate means to regulate the speed of a DC motor? Do you have any ideas for improvement?
Although the increase of the gain could reduce the error and help in regulating the DC motor, the motor is a nonlinear device, and cannot take large gain as its current will saturate. So it is not adequate to regulate the speed of a DC motor using proportional control. For improvements, we should use a model that considers the limitation of the DC motor.