<u>Engineering 446</u>

Control Systems Laboratory

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Lab Assignment #6
Simulation and Speed Control of a DC Motor

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Introduction

The goal in this laboratory assignment is to simulate a commonly used DC motor system in Simulink. This is a type of motor that is typically used to provide rotary motion. The tort produced by the DC motor can be utilized to drive an external Rotary mechanical load. The current drawn by the motor depends on its inductance as well as this given resistance. This laboratory assignment will challenge the user by requiring a implementation of a model of a small DC motor with the specifications provided in the report. There'll be conditions set in the simulation that will provide results that will simulate conditions of no load and full load. Separate simulations will be implemented to show each condition.

Problem Definition

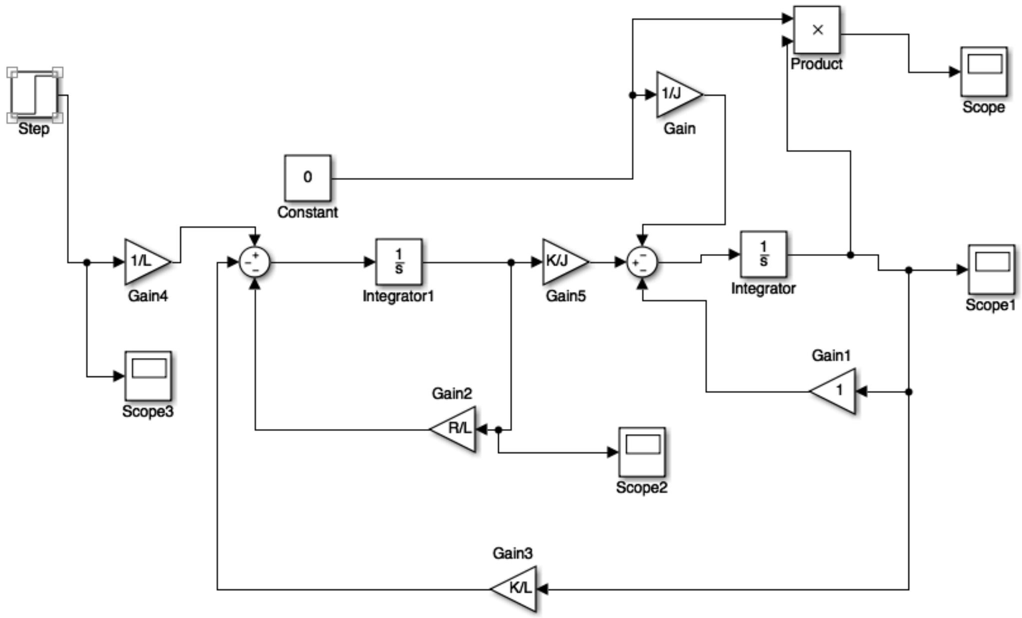
The system will be designed under the parameters and specification designated by the lab instructions. The DC motor System Will be made using a combination of the gain and some injunctions amongst other blocks. The response of the system will then be simulated under conditions a full load and no load with an external source. The next portion of the lab will implement a closed loop motor Control. The DC motor that was created in the previous part as a subsystem will be utilized in this implementation. The simulations will run for approximately 10 seconds each and the speed and voltage Will be plotted as an output.

Explanation of the experiments

The goal in this laboratory portion of this assignment is to realize a Simulink model of a small DC motor utilizing a differential equation. It is always convenient to use matlab and Simulink to create a simple System using some injunctions Game an integrator blocks whose parameters are conveniently provided in this particular laboratory assignment.

Given all the required data for the inputs to the system that is required to be developed the user can now move on to the second phase which is to simulate the response of the motor to a step input voltage of a Frida Dustin magnitude given at 20 V. The simulations to take underway at no load conditions as well as that full load external port conditions. We are then set to look at the simulation results and give an estimate of the settling time as well as the peak overshoot and of course the rise time of the system. A table will be made to conveniently and accurately portray these results. As a reminder to the user the conditions of no-load reverse to a condition at which no external torque is being applied. Whereas the full load condition is characterized and defined by the speed and external load at which the power delivered to the external load is a maximum provided at the given motor supply voltage is indeed 20 V. hey multiplier block as well as a scope block will be used as a power meter to visualize the conditions.

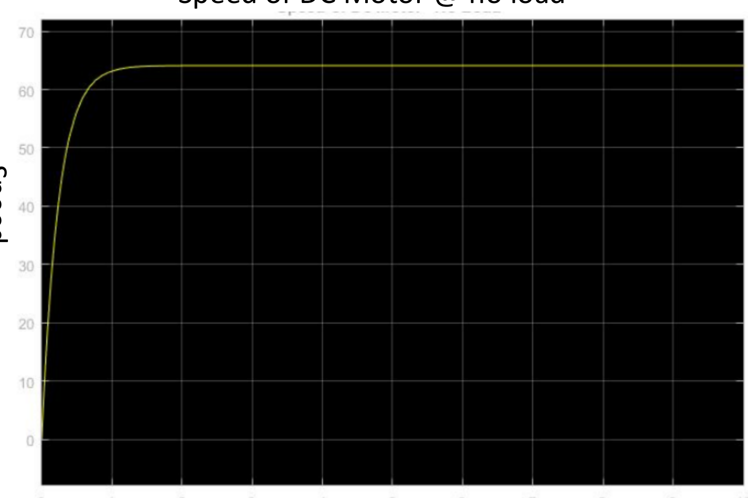
Models/Calculations/ Simulation Results



First step in this assignment is to setup the Simulink model as indicated by the laboratory directions.

The simulation is setup to show a system @ no load conditions by setting $T_x = 0$

Speed of DC Motor @ no load



Speed

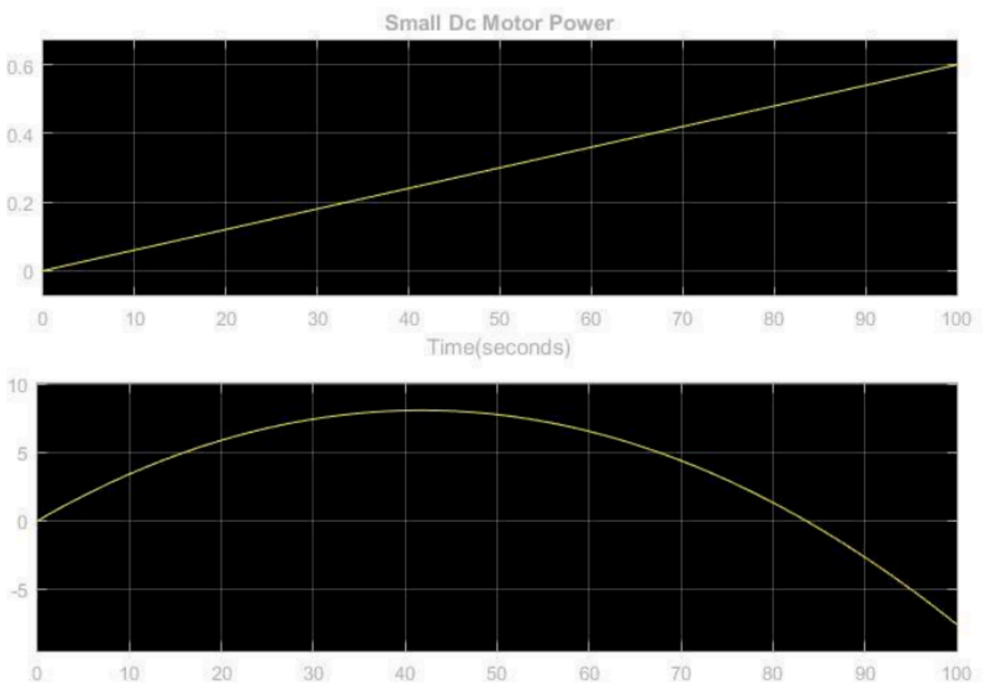
Time (seconds)

Settling Time	***0.9290***
Peak Overshoot	***4.65x10-4***
Rise TIme	***0.5222***

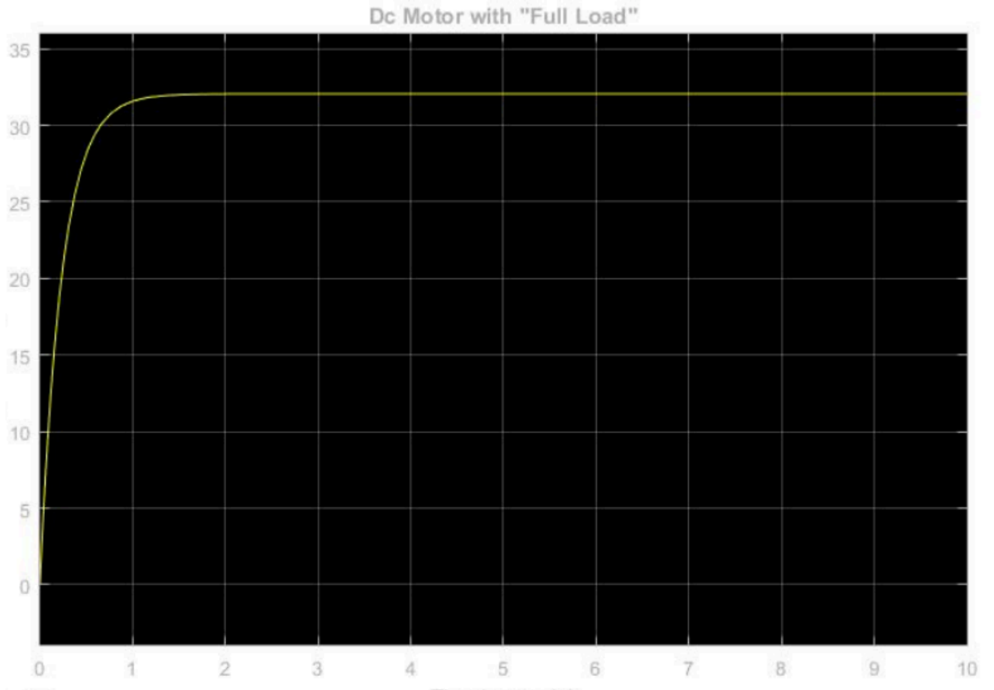
The data above was found using the information command in matlab

It takes about 0.93 seconds to reach the max value of 64.

The next task is to find T_x,f and P_{max}, to do so the user will add a ramp input instead of using a constant for the input to T_x. Creating a Power meter by using a Product box and using the output as well as the input of T_x. The simulation results in the following plots.



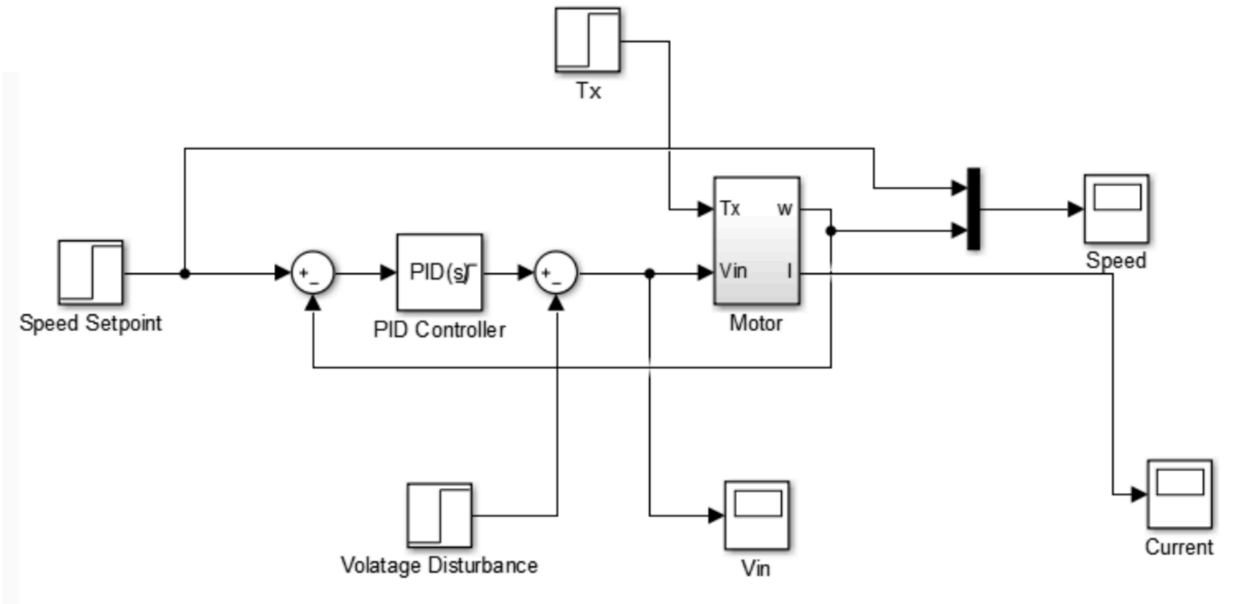
The user can observe the power scope when the Torque is connected to a ramp input to find the necessary variable values The Cursor tool can be used to find P_{max}, at the max we get a value of around 8, so at the value input of 8 we can find that Tx and fl which is around .26. We now know the input value will be at “Full Load”. We must plug in .26 to find the speed of the motor at full load which is shown below:



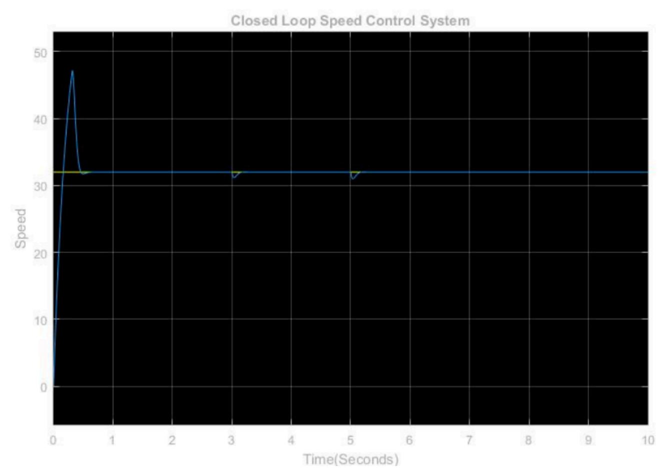
Settling Time	***0.9471***
Peak Overshoot	***3.6x10-8***
Rise Time	***0.5244***

Max @ 32.0

For the section that follows the motor is put into a subsystem and a pi controller/ tach are added …

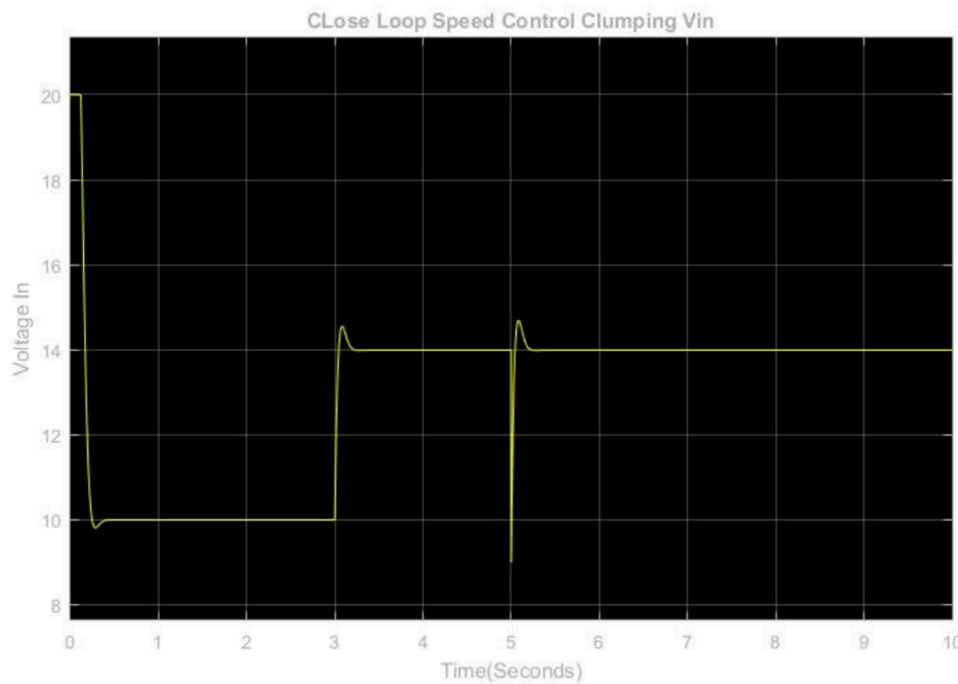


Here, the speed is set to a final value of 32 while the voltage disturbance is at a final value of 5 and step time of 5, T_x is set to a final value of 0.1 and a step time of 3. The following data is generated…

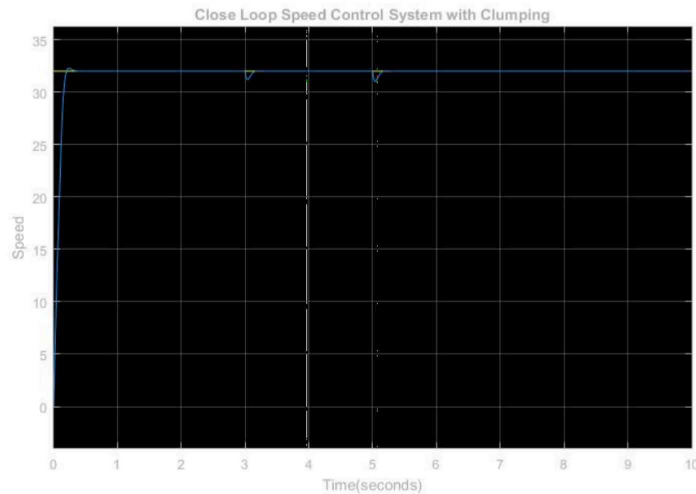


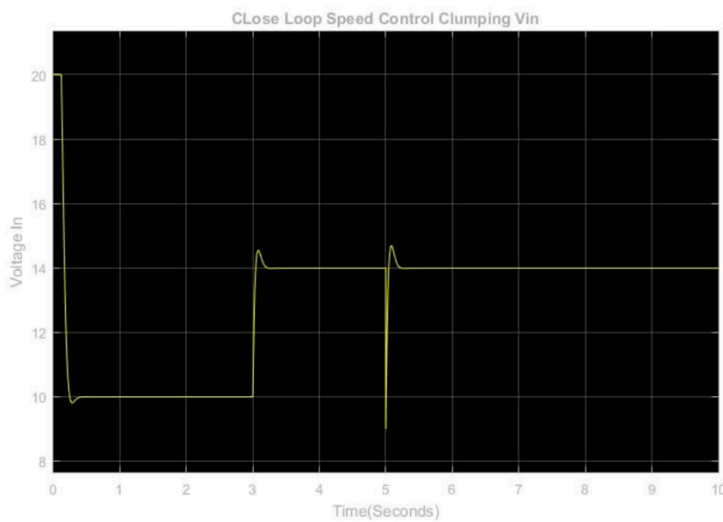
The speed input to begin is 32 rad/s with no external torque. The data does indicate a sudden spike in speed, while overshooting the speed step input then quickly digresses to the step input.

At time t=3, a torque step input of T_x=0.1, corresponding to a sudden torque demand by the load. The graph above indicates this trend by a little drop in speed which is justified because the additional torque slows down the speed of the motor however the system quickly fixes the problem and it reaches the step again. Lastly, at t=5 there is a disturbance step of 5 Volts, this is simulating a sudden drop in the motor supply voltage. This slows down the speed of the motor but the system again quickly recovers and is able to bring the speed back up to fix the problem.



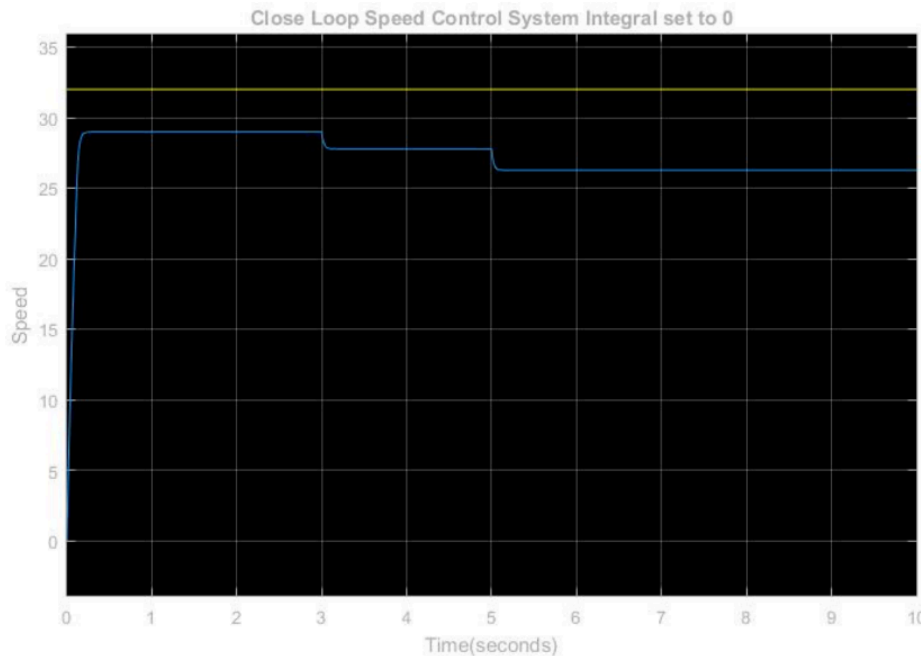
The anti-windup method is changed in the next step. We will set it to “clamping” while all other variables remain constant. Here is the plot of V_{in} vs speed.





As a result, we can see here that the response is a drastic improvement due to turning on the anti-windup feature. The excess overshoe is compensated for in the offset of the errors in the other direction is made when the anti-windup feature is enabled. If torque or disturbance is added the output will not change. This would make sense to the experimenters since the anti-windup feature only works on the wind up and not disturbances that happen in the system otherwise.

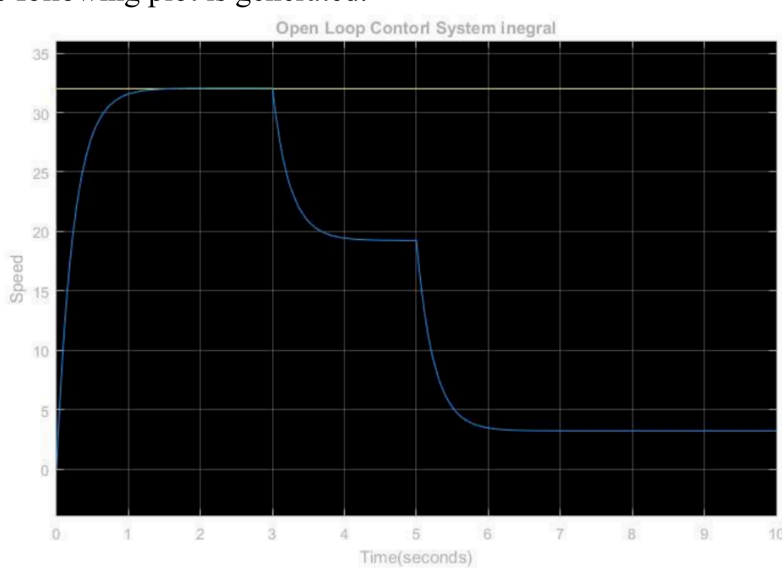
The next step is to set the PID block integral to 0 while leaving everything else the same and the following data is plotted:



When the integral is changed to 0 it dramatically effects the system by adding steady state error.

While there is more steady state error at each disturbance the system does not proceed to correct itself as intended. The PID action is compared with the open loop behavior by deleting the PID block and replace it with a step input block and setting the step input to 10 volts.

Lastly the following plot is generated.



This system acts like an open loop system and it had a slower rise time but does not overshoot like in the first part of this lab. With added disturbances the speed will keep slowing down and eventually does go back to the steady state like in part b.

The PID can make a huge difference since it helps the system reach the steady state speed.

Conclusions

So in this laboratory assignment refers worked to develop a small DC motor from the given differential equations. The simulation of the motor with no load and full load conditions was enacted. From the models we were able to learn that with no load the system reaches a faster speed much quicker than with full load, this make sense to us as engineers and as expected. The rent was used to find a full load conditions into find the designated variables. We learn with the DC motor looks like in full load conditions which drastically slow down the motor and make it harder and takes longer to reach the steady-state value. The rice time is the same for both. When the PID controller is set with anti-windup configuration enabled we found that it helps and fixing the overshoe in the beginning wind up by helping to reach steady-state value much faster. This lab help to understand PID controllers and their function as to how they can affect a system by changing some of the parameters.

List of References

"Simulink Basics Tutorial", SFSU 446 Laboratory manual book. Provided by University.