RENSSELAER MECHATRONICS

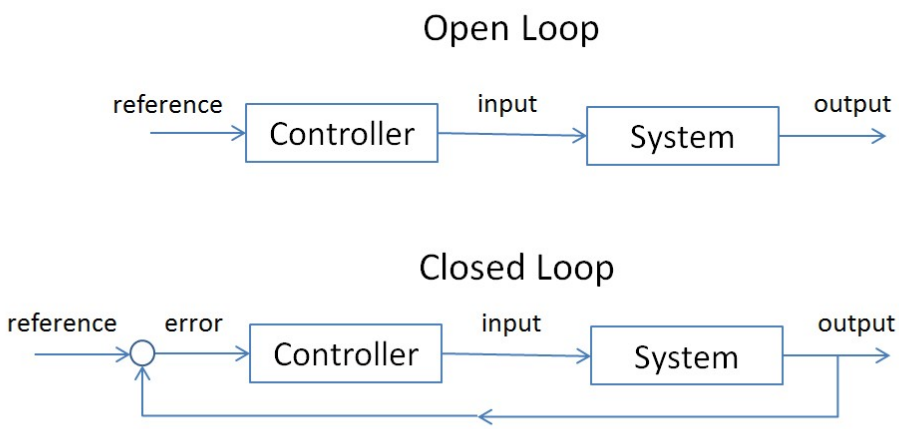
Basic DC Motor Position Control

Objectives:

- Control the position of the motor shaft
- Introduce basic control concepts
    - Closed loop feedback control
        - Instability: delays and controller gain

Background Information:

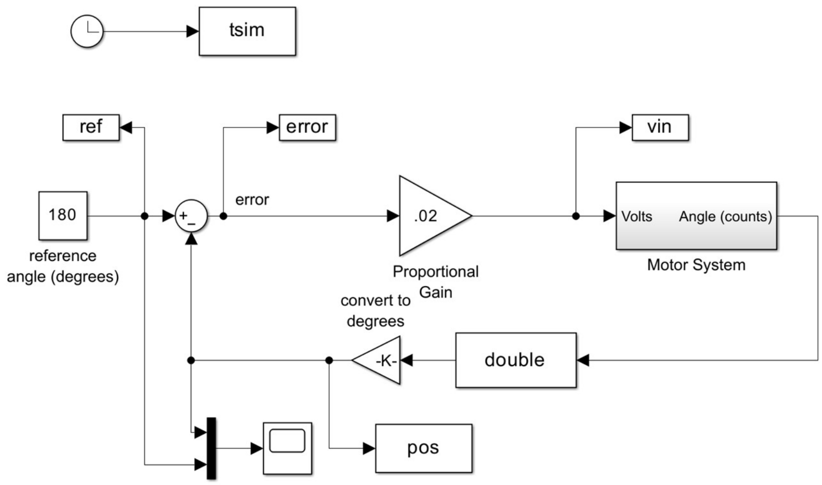
Controlling the output without directly measuring the output is called Open Loop control. If the output is measured and this information is used in the control this is called Closed Loop feedback control:



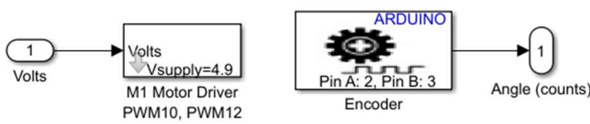
Measuring the output of interest and using this information in the control design is called closed loop feedback control. The basic strategy is to measure the output of interest, compare this to the desired output to generate an error signal and then try to reduce this error.

Proportional Control:

Build the following Simulink diagram:



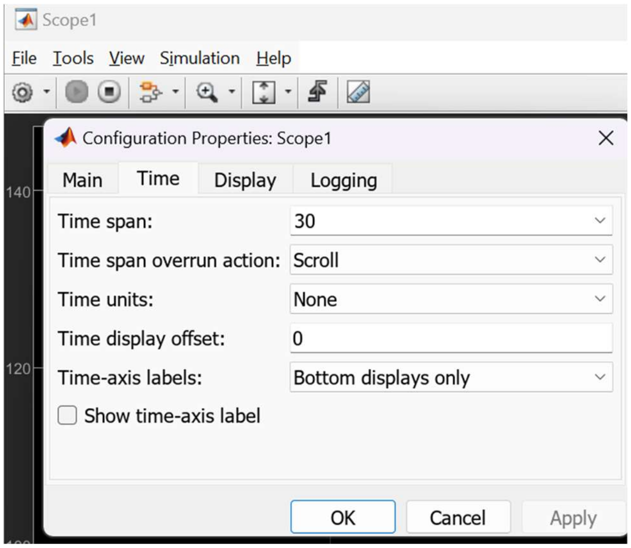
The motor system is a subsystem created from the following blocks (review how to make a subsystem from previous labs. Use appropriate driver and encoder blocks for your system):



- **Make sure your battery switches are set to 'ON', 'BATT', and 'OFF' for the Driver Enable, Driver Voltage, and the PWR Switch.**
- What value should be used to convert from the output in counts to degrees?
    - Verify this value. While running the code set the proportional gain to 0 (this turns off the motor). Turn the output motor shaft 1 revolution – do you get 360 degrees? If not calculate the correct gain and try again until you are SURE it is correct.
- If the position is initially zero and the control law is V=Kp*(reference – 0), what is the maximum gain before the controller will saturate (demand more voltage than is available) when the reference is 180 degrees?
- Run the Simulink diagram. **If the error does not decrease initially the measured value may need to have the sign changed (since the motor is going in the wrong direction). This is shown as a negative in the 'Proportional Control Gain' block, but should be placed inside of the motor system).**
    - Use a time step size of .03 seconds in external mode
    - Since the initial gain is zero the system should remain at rest
    - Change the proportional gain to .005 then change the reference to 180 then back to zero
    - Change the proportional gain to .01 then change the reference to 180 then back to zero
    - What value of the gain gives you a response that has the least error?

- What do you notice about the position of the motor shaft – does it move 180 degrees?

At this point, if you have observed the motor changing as you change the gain it will be easier to replace the constant with a pulse generator block. Change the constant block to a pulse generator block with amplitude 180, period of 3 seconds and a pulse width of 50%. Keep the simulation time infinite ('inf') and change the scope settings to "scroll" instead of "wrap" and use 30 seconds for the x axis in the setting so it is easier to observe the changes.



While this code is running change the gain from .005 to .01 to .02 and verify the same behavior with the constant block.

Modify simulation settings

- Change the time step size to .1 seconds and run in monitor and tune
- Change the proportional gain from .005, to .01 to .02. What do you notice?

Questions:

For this section **use a pulse generator block** with amplitude 180, period of 3 seconds and a pulse width of 50%. Use a stop time of 6 seconds – this will give you a couple step responses. Save the data for each test so you can easily plot a summary of your tests.

- Create a single plot that shows the reference and position vs. time for the following cases (you may want to use the 'save' command to save your data between each experiment for plotting later)
  - Step size of .03:
    - proportional gain of 0.005
    - proportional gain of 0.01
    - proportional gain of 0.02

- Create a single plot that shows the reference and position vs. time for the following cases
    - Step size of 0.1:
        - proportional gain of 0.005
        - proportional gain of 0.01
        - Proportional gain of 0.02

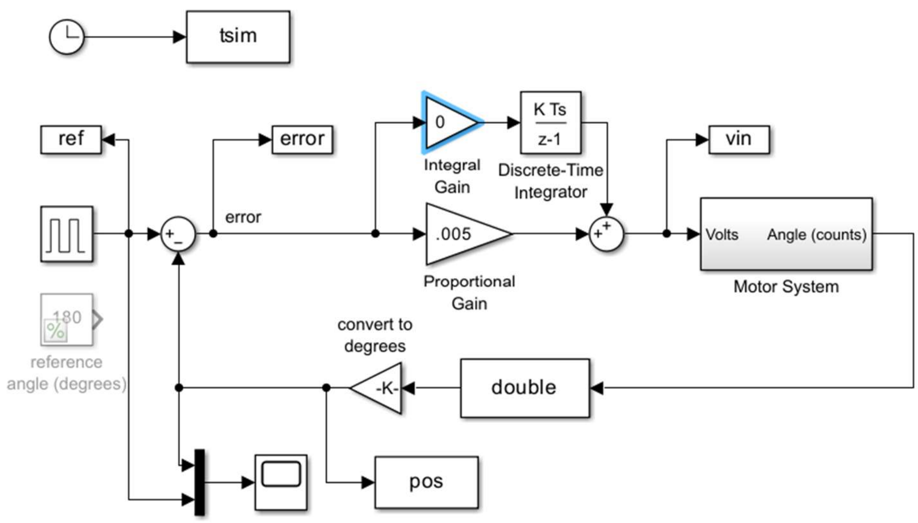
    Comment on the effect of the varying the gain on the control system performance (steady state error, speed, stability). Does it get to 180?

    Comment on the effect of the varying the step size on the control system performance (steady state error, speed, stability). How does the step size affect the performance?

Proportional Plus Integral Control:

Proportional only control does not eliminate the steady state error. If the error signal is integrated this value will keep increasing as long as there is a steady state error, and a control effort can be applied that will reduce this error.

Build the following Simulink diagram:



- Run this on the system.
    - Use a time step size of .03
    - Change the pulse period to 30 seconds (this gives you a long time to see the results), change the display on the scope to display 60 seconds

- Change the proportional gain to .005, integral gain to zero, then the reference to 180 on the scope – the response should be the same as before with a noticable steady state error.
  - About what amount is max steady state for a couple of pulses?
- Change the integral gain to .005. What do you observe? Can you find a value that gets rid of the steady state error? How small can you make the error? Why can't you seem to get rid of the error?

Questions:

- Provide a sing single plot showing the reference and position vs. time for the following cases:

  Step size of 0.03:

  proportional gain of 0.005 and the best integral gain you could find to get the error as small as possible for more than 4 steps.