Basic DC Motor Position Control

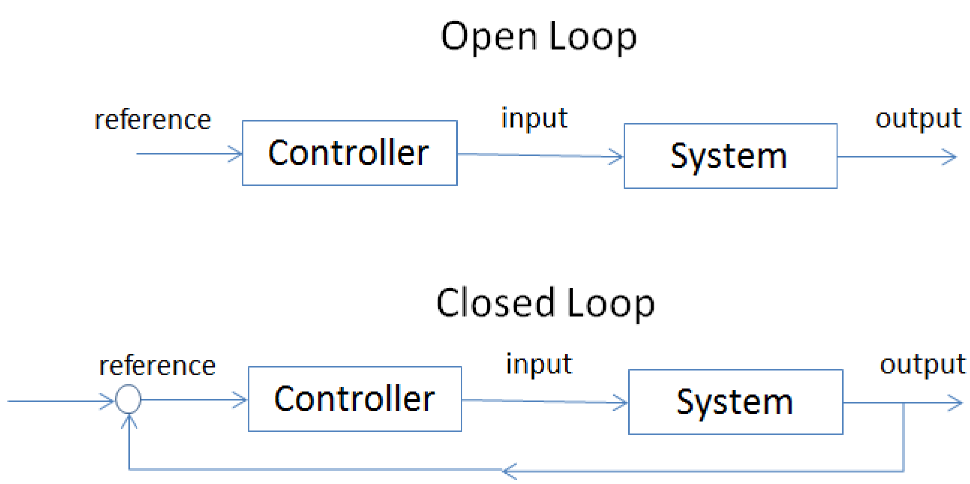
Objectives:

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

Part 1: Open loop position control

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:



Objective

Control the output of the motor shaft *without* using the shaft position.

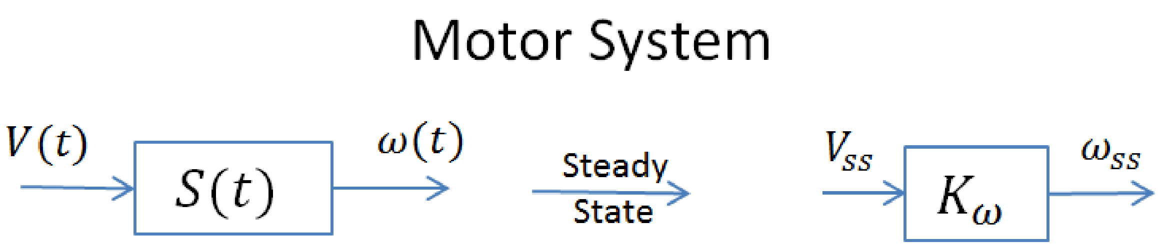
The general approach is:

- Learn about the system (develop a model)
- Use this information to control the response

For this simple example

- the steady state behavior of the motor will be investigated to understand how the speed varies with the voltage
- a constant input voltage can be applied for a specified time to move the motor to a desired position

In general the system dynamics will vary with time, but if the input remains constant, then the output angular velocity will also remain constant



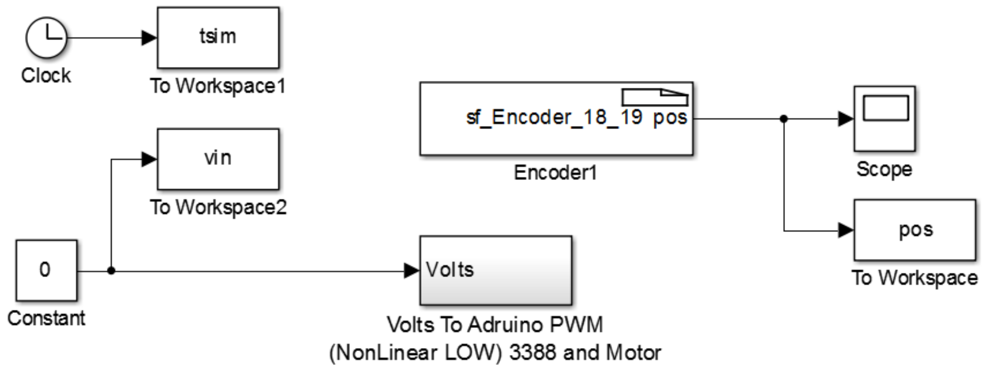
Assuming the angular velocity is constant the the position can be determined by integrating the angular velocity:

$$\theta(t) = \int_0^t \omega(t)dt \rightarrow \theta = \omega_{ss}t = V_{ss}K_\omega\, t$$

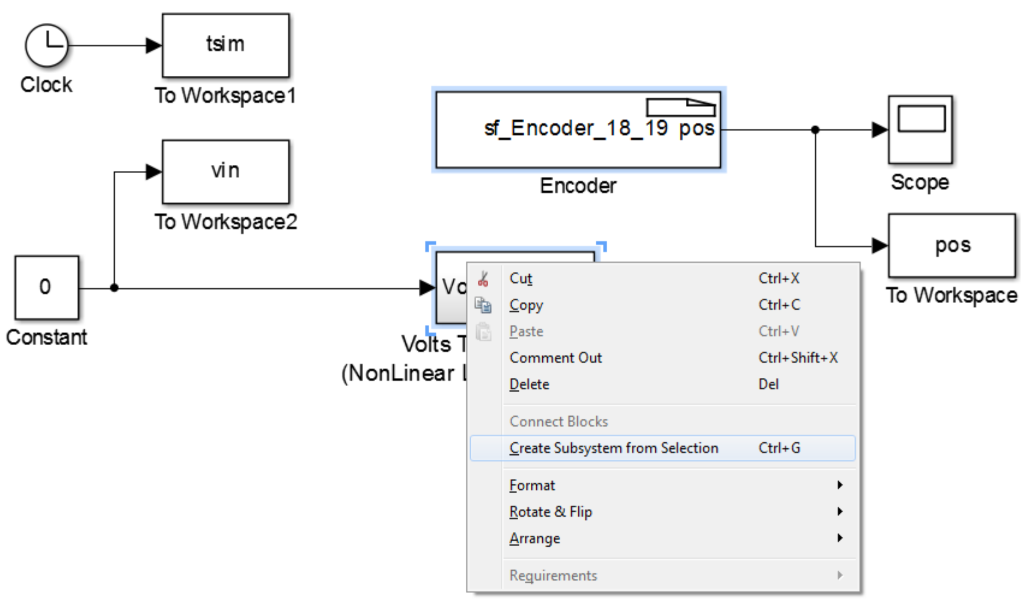
Once K_ω is determined the on time t can be determined.

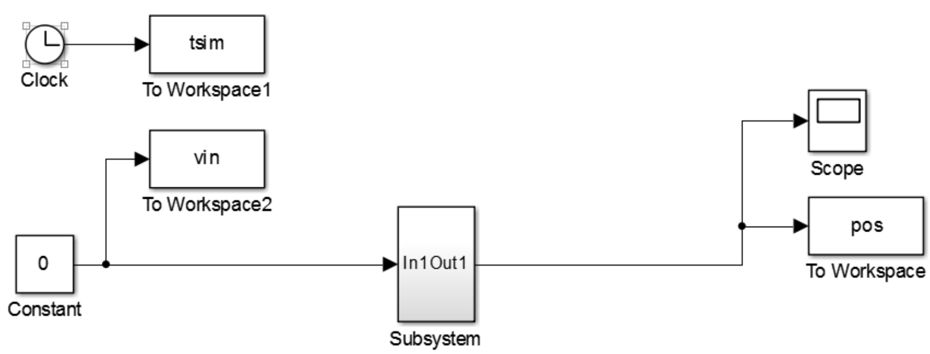
Simulink Model

Create the Simulink diagram below.

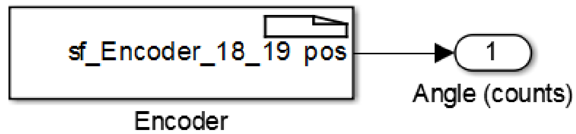


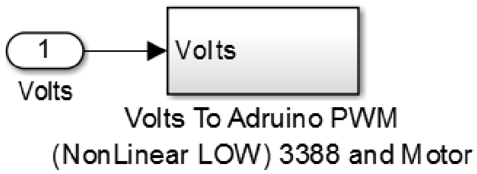
- To make the diagram more readable select both the “Volts To Arduino..” subsystem and the “Encoder” subsystem (hold shift button) and create a subsystem from them (right-click):



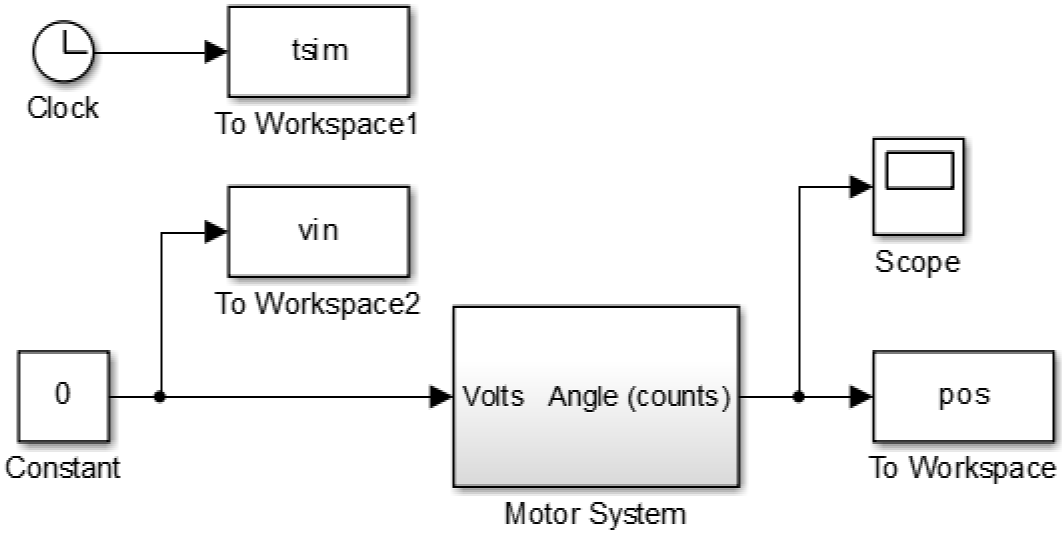


- Rename the subsystem, then enter the subsystem and change input and output ports to have meaningful names
    - The input is in volts, the output is the angle in counts



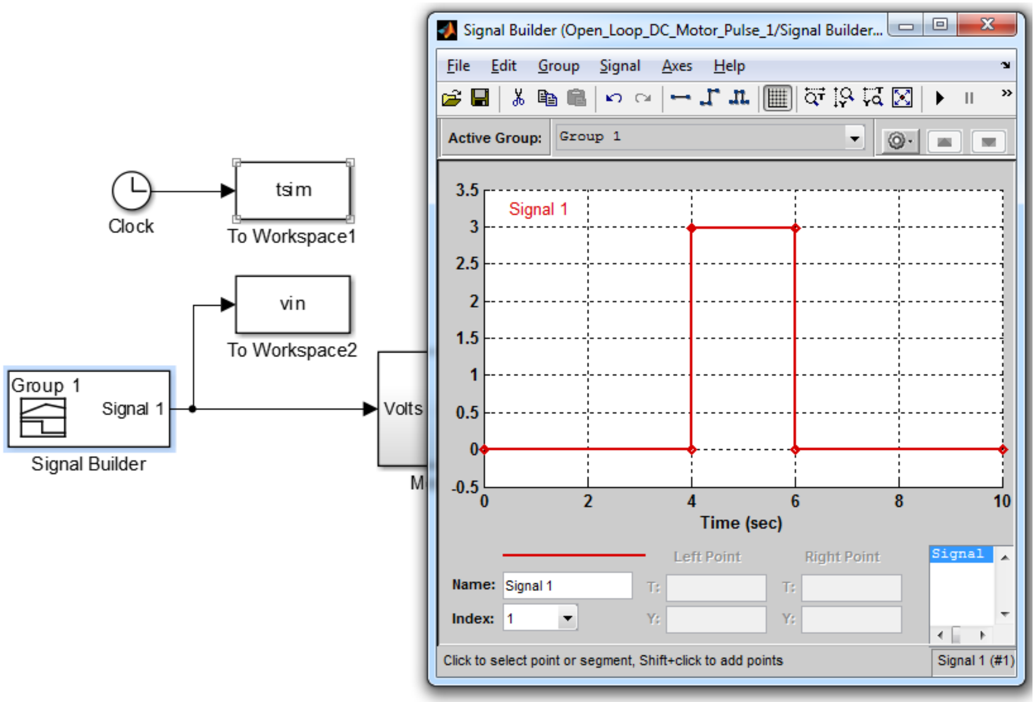


- Final Diagram



Determine K_ω in units of degrees/(sec*volts): (use external mode or serial mode to obtain the data, calculate the velocity in a script or in the simulink diagram)

- Run the system at 2 volts, determine the stead-state velocity, calculate K_ω
- Run the system at 3 volts, determine the stead-state velocity, calculate K_ω
- Determine the number seconds to apply to the motor at 3 volts to rotate 360 degrees using the steady state formula
- Apply this to your system to test the result:



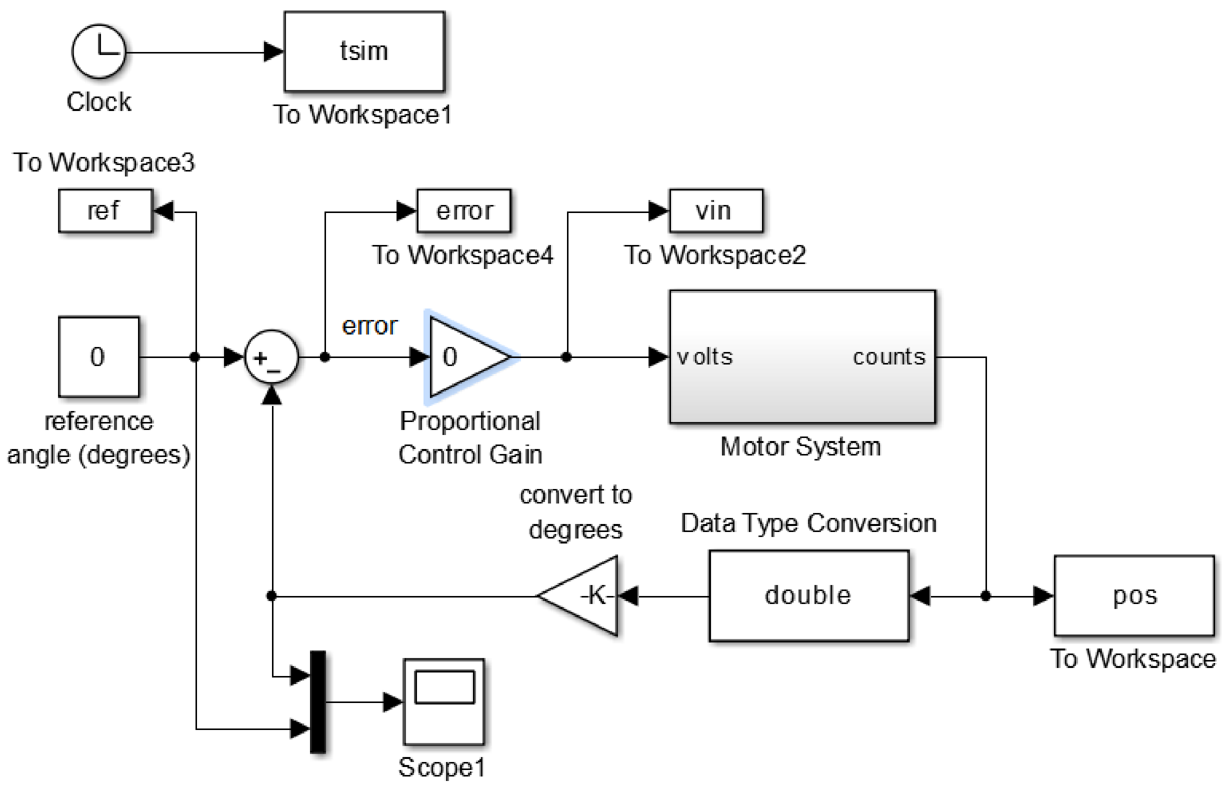
The result will be only as good as the system behavior can be predicted with the model. The assumption that the system behaves in steady-state the entire time may not be very accurate.

Part 2: 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:

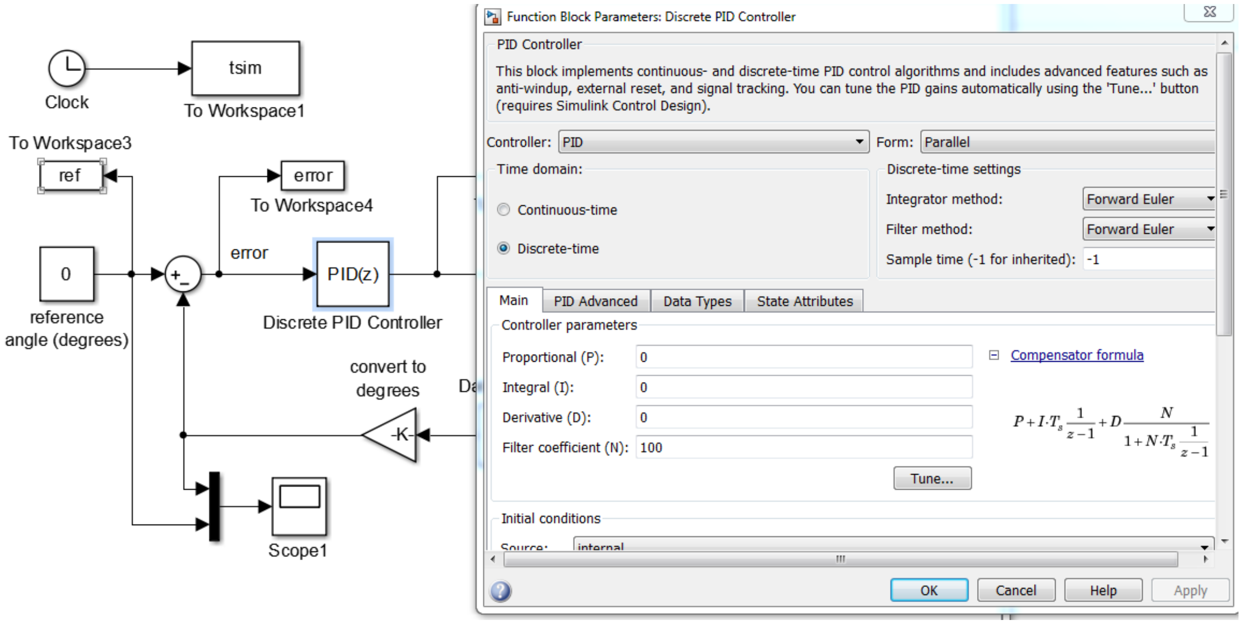


- What value should be used to convert from the output in counts to degrees?
- Run the Simulink
  - Use a time step size of .03 seconds in external mode
  - Since the initial gain is zero the system should remain at rest
  - Change the proportional gain to .05 then change the reference to 360 then back to zero
  - Change the proportional gain to .1 then change the reference to 360 then back to zero
  - What do you notice?
- Modify simulation settings
  - Change the time step size to .1 seconds in external mode
  - Change the proportional gain to .1 then change the reference to 360 then back to zero
  - What do you notice?

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 is proportional to the integral of the error

Build the Simulink diagram:



- Run this on the system.
  - Use a time step size of .03
  - Change the proportional gain to .05, then the reference to 360 – the response should be the same as before with a steady state error
  - Change the integral gain to .1 – what do you observe?