One of the most important components of a control system is the actuator. Many systems rely on an electrical actuator, and among these, DC motor continues to be the most popular choice. In this experiment you will explore the behavior of a DC motor and learn how it is used in control systems.

**Remember to save all your work on a floppy disk.**

1. A typical input to an electrical motor is a pulse:

   \[
   p(t) = A \left(1(t - T_s) - 1(t - T_f)\right). \]

   If \(1(t)\) is a unit step function, a pulse in the figure can be defined as:

   \[
   p(t) = A \left(1(t - T_s) - 1(t - T_f)\right). \]

   Use the Simulink to implement a pulse as an input function. Use the **Step** block in the **Sources** library and the **Sum** block in the **Math** library. Assume that \(A = 1\), \(T_s = 1\) and \(T_f = 2\). Verify your design with a simulation using a **Scope** block. Print the result of the simulation.

   *Hint:* If you click on the **Step** block you can set the amplitude and the location of the step.

2. We would like to see how a field-controlled motor responds to a pulse. Implement the following block diagram:

   ![Field-controlled DC motor diagram](image)

   The parameters of the motor are:

   \[
   R_f = 1, \quad J = 2, \quad K_m = 10, \quad L_f = 0.1, \quad b = 0.5
   \]
(a) Use the Transfer Fcn block in the Continuous library to implement each transfer function. You can change the coefficients of the transfer function by clicking on the block. Let the input $V_f$ be the pulse you implemented above. Set the disturbance to be a Constant block in the Sources library. Set the value of the constant to 0.

(b) Using the Mux block, connect the output of the motor $\theta$, the torque $T_m$ and the input $V_f$ to a scope. Set the Stop time for the simulation to 40. Open the scope window and run the simulation. Click the right button on the scope window to Autoscale the plot. Print the result.

(c) Now set the value of the disturbance torque $T_d$ to 0.1. Run the simulation again, Autoscale the plot and print the result. Comment on the difference from the previous simulation.

3. We would like to compare the performance of the field-controlled motor with that of an armature-controlled motor:

![Armature-controlled DC motor diagram](image)

(a) For the same parameters as above and assuming $R_a = R_f$, $L_a = L_f$, $K_b = K_m$, draw the block diagram of the armature-controlled motor in Simulink. Use the pulse for the input and 0 for the disturbance torque $T_d$.

(b) Using the Mux block, connect the output of the motor $\theta$, the torque $T_m$ and the input $V_a$ to a scope. Set the Stop time for the simulation to 40. Open the scope window and run the simulation. Click the right button on the scope window to Autoscale the plot. Print the result.

(c) Compare the performance of the armature-controlled motor with that of the field-controlled motor. In particular, comment on the torque response, $T_m$. Based on the shape of $T_m$, which configuration seems simpler to use?