



ANKARA UNIVERSITY
Engineering Faculty
Department of Electrical and Electronics Engineering

Experiment-3

EEE 360 Control Lab

FEEDBACK CONTROL SYSTEM

CHARACTERISTICS

Objectives of the Experiment:

- Learn basics of LabVIEW
- Construct feedback control systems and observe the time response properties of systems on labview environment
- Understand the impact of the parameter change in the control systems.
- Learn the Simulation window and related topics of LabVIEW

1. Preliminary Study:

1. Please read experimental study section to understand what you are going to do in the experiment.
2. Research on related topics in computer programs like Matlab or Scilab. Prepare yourself for the experiment.
3. The shoulder joint of a robotic arm uses a DC motor with armature control and a set of gears on the output shaft. The model of the system is shown in Figure with a disturbance torque $T_d(s)$ which represents the effect of the load. Determine the steady-state error when the desired angle input is a step so that $\theta_d(s) = A/s$, $G_c(s) = K$ and the disturbance input is zero. When $\theta_d(s) = 0$ and the load effect is $T_d(s) = M/s$, determine the steady state error when

- (a) $G_c(s) = K$
- (b) $G_c(s) = K/s$

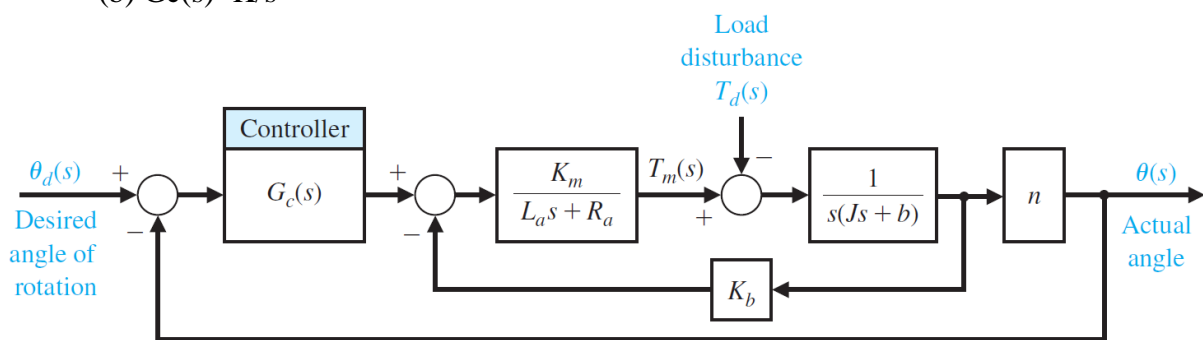


Figure 1. Robot Joint Control

4. Figure 2 shows the model of a two-tank system containing a heated liquid, where $T_0(s)$ is the temperature of the fluid flowing into the first tank and $T_2(s)$ is the temperature of the liquid flowing out of the second tank. The system of two tanks has a heater in the first tank with a controllable heat input Q . The time constants are $\tau_1 = 10$ s and $\tau_2 = 50$ s.
 - (a) Determine $T_2(s)$ in terms of $T_0(s)$ and $T_{2d}(s)$.
 - (b) If $T_{2d}(s)$, the desired output temperature, is changed instantaneously from $T_{2d}(s) = A/s$ to $T_{2d}(s) = 2A/s$, where $T_0(s) = A/s$, determine the transient response of $T_2(s)$ when $G_c(s) = K = 500$.
 - (c) Find the steady-state error e_{ss} for the system of part (b), where $E(s) = T_{2d}(s) - T_2(s)$.

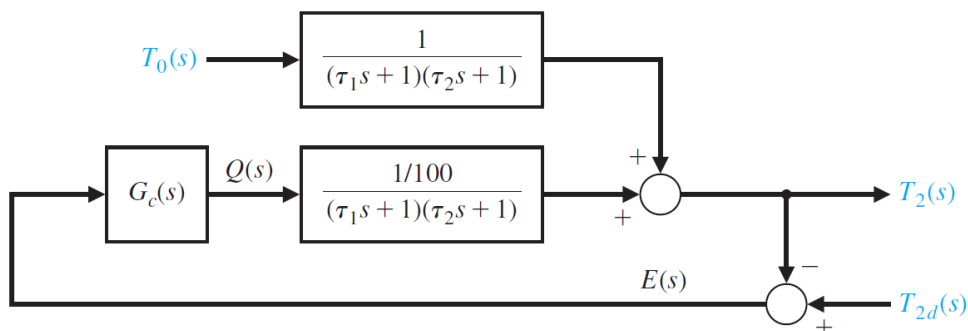


Figure 2. Temperature Control System

5. Plot output for Figure 1 and 2 where all inputs are step functions (use Matlab or Scilab). Select unknown parameters randomly (if any).

2.Experimental Study:

This section is given in two parts. The application in the first part (Repeat the Steps) is expected to be repeated by the student and to find the same result obtained. Thus, the student understands the subject and learns how to use it. In the second part (Do it Yourself), the jobs to be done are listed, but they are not explained how to do them. He solves and fills in the datasheet using the information (s)he learned in the first part and what he did in the preliminary study.

Look at the Experiment 1 and 2 documents. Be sure you learn every step at the previous experiments. You may need the information from the previous experiment.

2.1. Repeat the Steps

The principle of superposition applied to linear systems where two inputs are applied as shown in Figure 3. We can use Labview to compute transfer function from $T_d(s)$ to $w(s)$ and we can obtain output response under unit step disturbance. The parameters for the Figure 3 are given in Table 1.

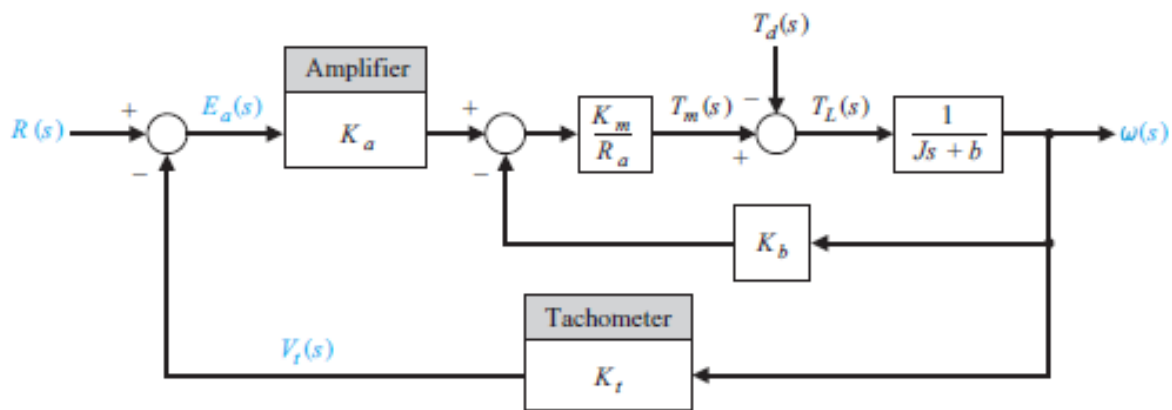


Figure 3. Closed-loop Control System

It is possible to use **MathScript** tool inside Block Diagram such that some Matlab functions like (**tf**, which gives the transfer function). The modules in the LabVIEW are **CD Draw Transfer Function equation**, **CD Step Response**. You can find on the LabVIEW Environment (Please look at previous Experiment to get the exact position of these tools)

Table 1. Control System Parameters

Ra	Km	J	b	Kb	Ka	Kt
1	10	2	0.5	0.1	54	1

Please look at Figure 4 to get Block Diagram and Front Panel of the desired system in Figure 3. Also, in the Front Panel figure the output of the system can be observed. Please understand the outputs of the system.

Add **Cluster** from **Array Matrix and Cluster** toolset. Then add Numerical Indicators inside the cluster as inputs of the MathScript. Select **Unbundle to Name** symbol inside **Array Matrix and** toolset.

To get equation right click **Equation** small dot on **CD Draw Transfer Function** block.

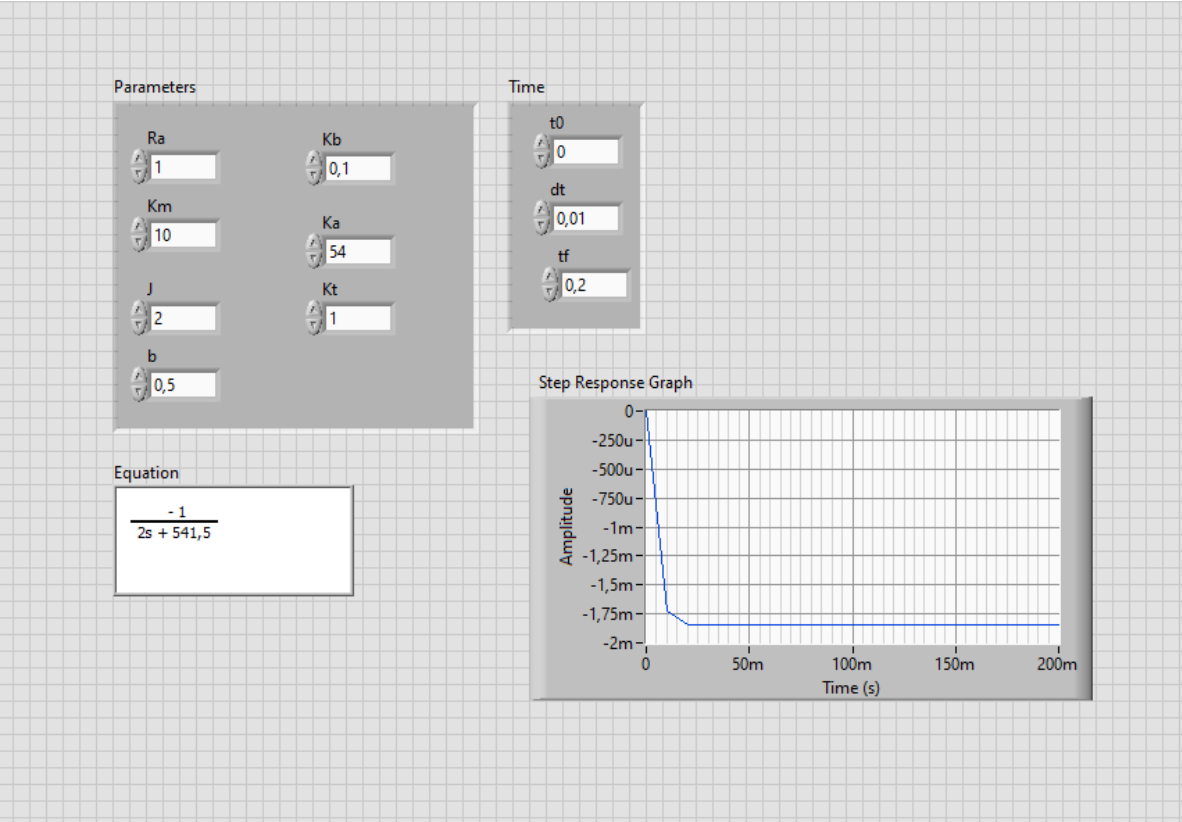
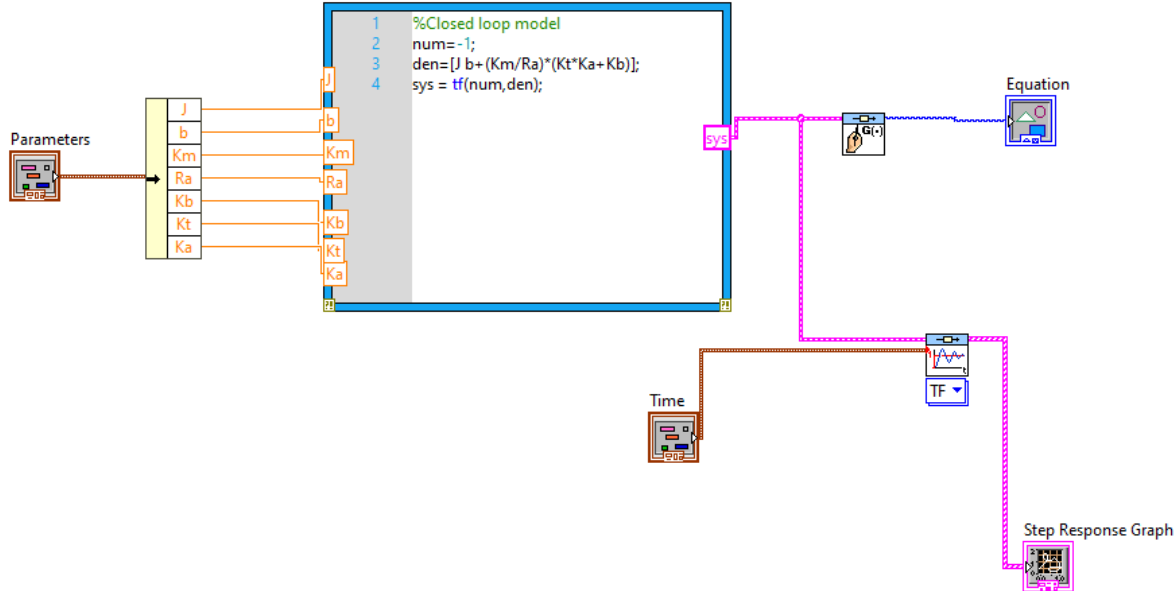


Figure 4. Block Diagram and Front Panel of the System Given in Figure 3

2.2. Do it Yourself!

1. For the transfer function given below

$$Y(s) = \frac{K + 11s}{s^2 + 12s + K} R(s).$$

Construct on Labview to get step Response of the system for the different K values given in B1. Observe and record overshoot, steady state error, and settling time for different K values. Draw step response for K=20 into A1. What is the impact of the parameter K on the step response of the system?

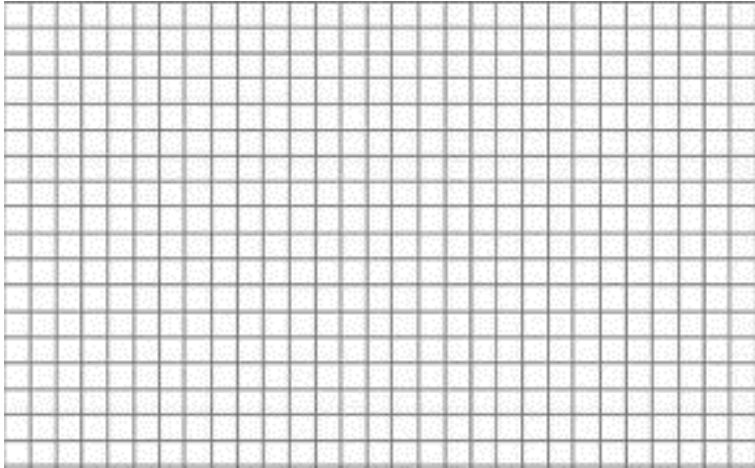
2. Consider the system given in preliminary work Figure 2, where time constants are $\tau_1 = 10$ s and $\tau_2 = 50$ s. $T_{2d}(s)$ is $T_{2d}(s) = 1/s$ and $T_0(s)$ is the input, determine the step response of $T_2(s)$ when $G_c(s) = K$ given in B2. Observe and record overshoot, steady state error, and settling time for different K values. Draw step response for K=20 into A2. What is the impact of the parameter K on the step response of the system?

Data Sheet (Student Copy):

B1

K	Settling Time	Overshoot	Steady State Error
5			
10			
20			
25			

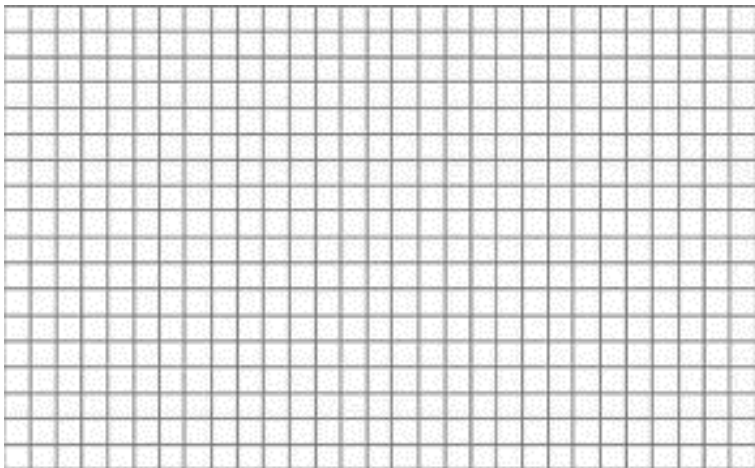
A1



B2

K	Settling Time	Overshoot	Steady State Error
500			
250			
100			
300			

A2



Names of students in the group:

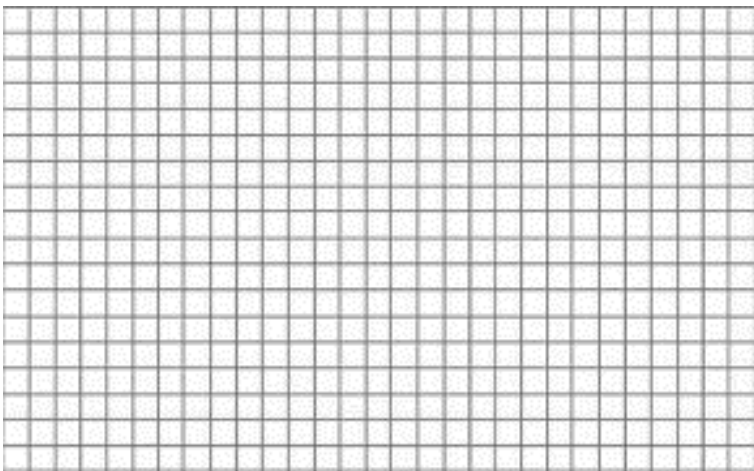
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Data Sheet (Instructor Copy):

B1

K	Settling Time	Overshoot	Steady State Error
5			
10			
20			
25			

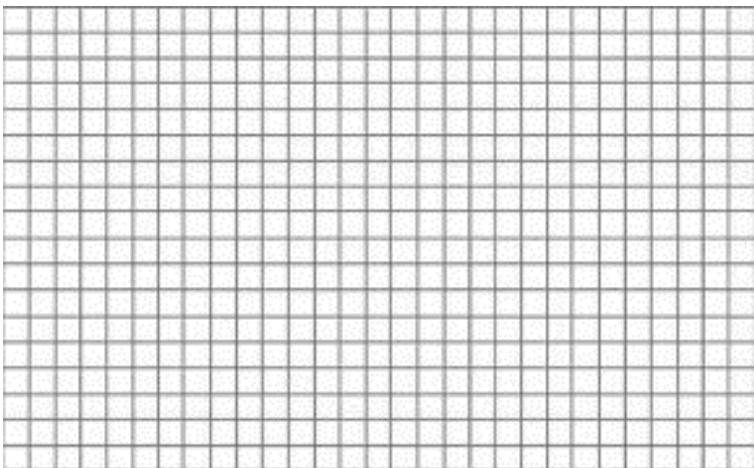
A1



B2

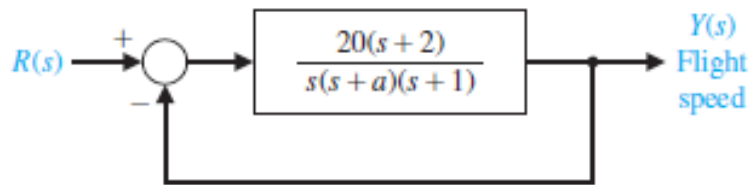
K	Settling Time	Overshoot	Steady State Error
500			
250			
100			
300			

A2



Report:

1. Please answer all the questions give in experimental study. Please use Data Sheet you obtained from the experiment.
2. Re-make the calculations in preliminary study questions.
3. Explain your outcomes from the experiment.
4. A proposed hypersonic plane would climb to 100,000 feet, fly 3800 miles per hour, and cross the Pacific in 2 hours. Control of the aircraft speed could be represented by the model in Figure. Find the sensitivity of the closed-loop transfer function $T1s2$ to a small change in the parameter a .



5. Two feedback systems are shown in Figures.

(a) Evaluate the closed-loop transfer functions $T1$ and $T2$ for each system.

(b) Compare the Sensitivities of the two systems with respect to the parameter $K1$ for the nominal values of $K1 = K2 = 1$.

