Design and Construction a Set of Linear Control Laboratory

Davood Davoodi
Khavaran Higher Education Institute student
Email: davood.davodi@gmail.com
Mahnoosh Shajiee
Lecturer of Islamic Azad University, Mashhad branch
Email: ma.shajiee@gmail.com
Paper Reference Number: 12516700
Name of the Presenter: **Davood Davoodi**

Abstract

This control set designed and built for the first time by a student. The purpose of design is to better understand the benefits of control systems and comparison theory with practice. View the effect of changing parameters of a system as well as all the effects to impose a compensation controller system that parallel or series can be used in the system. Also being familiar with how the design principles and building a system with equivalent electronic circuits, especially operational amplifier has been studied. Responses of the blocks are designed with the same block in response to content was the same as in Matlab software and in most cases are without any error. One of the obvious advantages of this set is that the noise level which in control systems is very important, in this set is very low. Privileges of created set in comparison with similar sets on the market are more.

Key words: controllers, Design and modeling of control systems, Electronic circuits,

1. Introduction

When studying control systems the reader should be able to model dynamic systems and analyze the dynamic characteristics of them.

Mathematical model of a dynamical system is a set of equations in different states of the system to accurately or at least a good show [8].

Each system can be shown in different displays depending on individual perspective models. Dynamic behavior of many systems, including electrical, mechanical, thermal, economic, biological, etc can be described by differential equations. The differential equations can be gained by physical laws governing systems for example, Newton's law and Kirchhoff laws for mechanical and electrical systems [7].

In order to implementation of control systems, set of linear control laboratory made. This device can be used in Linear Control Systems Lab of electrical engineering, automatic control laboratory, mechanical engineering and chemical engineering process control laboratory. This set implemented as analog blocks and the circuit design is such that the effect of external noise on the system is very low.
To simulate various control loops in accordance with the classical linear control headings course is designed and built [1].
Response of system to various inputs in compare of the response of same system in MATLAB software is very close, that is of high accuracy has been designed.
In making this device more features than sets used in other training centers are considered, including the input noise, step, ramp, two-variable and three variable lead controller and lag controller.

2.*Data and Material*

This device includes parts of feeding, generating inputs of step and ramp, addition, subtraction circuits, various blocks with constant coefficients, block with the noise input, controllers such as KP, KDs, KIs apart from the other in two ranges (1- 0.1) and (1-10), two and three-variables structural compensators.
Considering the system transfer function using current and voltage laws kirchhoff derived. Whit using the integral and derivative circuits, design began.
The set Components are described as below.

2-1 Integrator Transfer Function

This transfer function is a basic linear control block which is most used in modeling mechanical or electrical systems. Also in Mason method and analysis of circuits in the state space plays an essential role.
To achieve this transfer function, the operational amplifier was used. Input and output relationship is as follows:

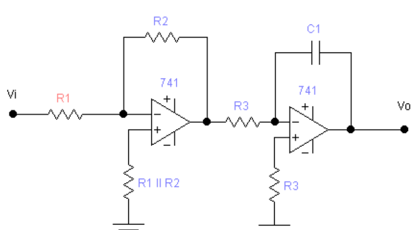

Fig. 1 $\frac{1}{s}$ Transfer function circuit

$$\begin{cases} \dfrac{V_o(s)}{V_i(s)} = \dfrac{\frac{1}{CS}}{R_3} = \dfrac{Z_3}{Z_1}, \\ \dfrac{V_o(s)}{V_i(s)} = \dfrac{1}{R_3 CS} = \dfrac{1}{S}, \\ R_3 CS = 1, \\ R_3 = 10K\Omega, C = 100\mu F, \end{cases} \tag{1}$$

2-2 First Order Transfer Function

Implementation of the first order system with different time constants of the form

$$G(S)=\frac{1}{Ts+1} \tag{2}$$

To achieve this transfer function the operational amplifier was used. Input and output relationship in the model function is as follows:

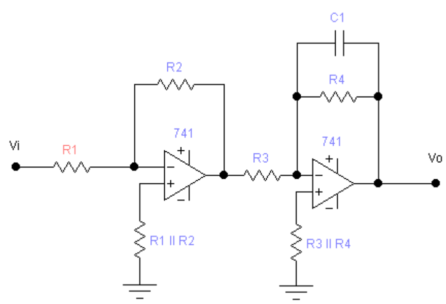

Fig. 2 $\frac{1}{s+1}$ Transfer function circuit

$$\begin{cases} \frac{V_o(s)}{V_i(s)}=\frac{Z_2}{Z_1}=\frac{R_2\left\|\frac{1}{CS}\right.}{R_1}, \\ \frac{V_o(s)}{V_i(s)}=\frac{\frac{R_2}{R_1}}{R_2CS+1}=\frac{1}{S+1}, \\ R_2CS=1, \frac{R_2}{R_1}=1, \\ R_2=10K\Omega, R_1=10K\Omega, C=100\mu F, \end{cases} \tag{3}$$

Also other blocks with $T=0.01, 0.001$ were built.

2-3 Proportional Controller K_p

Proportional controller essentially is an amplifier with adjustable gain that is included in this set. Different range for the intended change of 0.1 to 1 and other interest is from 1 to 10. If necessary to access more gain, by changing the potentiometer that considered in the design of manufacturing control set can be provided. The controller circuit design was made as following.

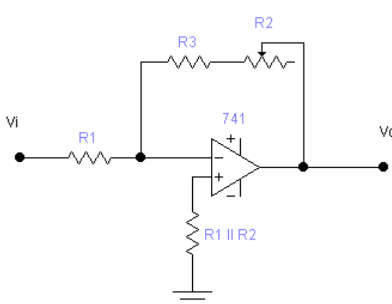

Fig. 3 proportional amplifier electrical circuit

2-4 Proportional Integral Controller Transfer Function $\frac{K_I}{s}$

The integral term (when added to the proportional term) accelerates the movement of the process towards set point and eliminates the residual steady-state error that occurs with a proportional only controller.

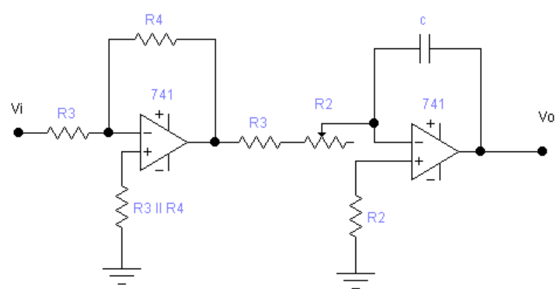

Fig. 4 proportional integral electrical circuit

2-5 Proportional Derivative Controller KDs

Derivative control is used to reduce the magnitude of the overshoot produced by the integral component and improve the combined controller-process stability.

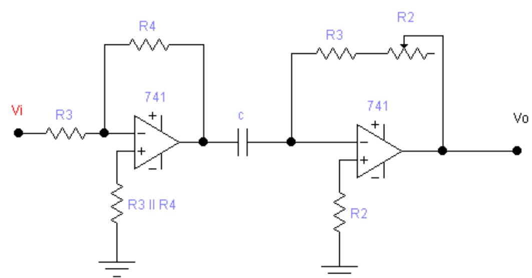

Fig. 5 proportional derivative electrical circuit

2-6 Lead-Lag Compensator

Controllers which are used to improve system parameters such as (steady state error, reducing resonant peak, improve system response by reducing rise time). All these operations can be

done by Compensators as well. Lead and lag compensator introduce a pole-zero pair into the open loop transfer function [2].
Different methods for construction of Compensators exist. Op-amp networks, RC electrical network and mechanical systems springs - shock are samples of this compensation. In practice, much compensation op-amp instruments are used.
The transfer function of three-variable compensator can be written in the Laplace domain as**:**

$$G_C(s) = K_c\alpha\frac{1+TS}{1+\alpha TS} \tag{4}$$

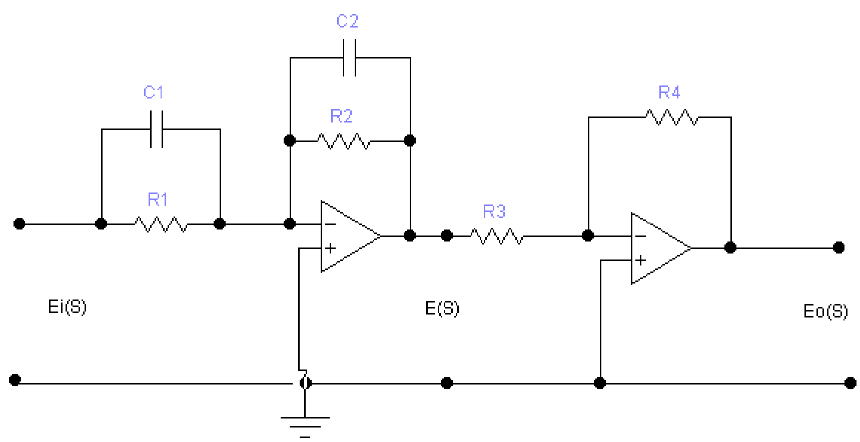

Fig. 6 Lea d-Lag electrical circuit

This circuit if $R_1C_1\rangle\ R_2C_2$ acts as lead controller and if $R_1C_1\langle R_2C_2$ acts as lag controller. Also two variables compensation in this device is included.

$$G_C(S) = \frac{\beta_1 S + 1}{\beta_2 S + 1} \tag{5}$$

With this compensation that you get series with the original transfer function can directly impact your change added to the pole and zero applied separately and be seen.

3. Research Methodology

The activity of research is to execute the practical system block. It provides advancement of look in these blocks objectively. It constitutes special attitude in students.

4. Results and Analysis

Answer all of the hardware blocks were made with the responses obtained in the MATLAB software environment were compared with the same answers that were resulting from this detailed hardware design is done.

5. *Conclusions*

With this device any hardware block can be tested. The advantages and disadvantages of each software and hardware procedures in control systems be investigated and compare this two responses.
The set that is made in comparison with similar devices on the market are having more features such as low price, noise input, ramp reference and high accuracy.
For better outcomes of this set, a digital function generator and digital scope recommended.
Another paper in this regard is in progress that includes analyzing the output signal in Matlab environment to achieve characteristics such as frequency domain analysis.

References

[1] Mousavi, M. (2007). principles and laboratory application of linear control systems, Sarafraz publication.

[2] A.Hla Myo Tun, S.San Hlaing Oo and C.Myint Myint Yi. (2008). Analysis of Phase Lead Compensator Design for Laser Guided Missile System using MATLAB. World Academy of science, Engeering and Technology 42

[3] Khaki Seddigh, A. (2000). Linear control system, Noor University

[4]Taghirad, H. (2002). Introduction to industrial automation and process control. Khaje Nasir University.

[5] Rezaee, A and Zahabi M. (2000).Electronic Measurement. Prof Hesabi publication.

[6] Doomani, A and Khaki Sedigh, A. (2005). Design of first order stable controller to achieve defined charactrestic. *ASCE 05 conference*. Cairo Eygept.

[7] Dorf, R and Bishop R H (2001). Modern Control Systems. 9th edition-Addison Wesley Publishing Company

[8] Kuo, B. (1995). Automatic Controls Systems, Prentice Hall, Englewood Cliffs, NJ, 7th edition.

[9]Jacob, M. (1989). Industrial control Electronics. Prentice Hall International