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Faculty of Computer & Informatics Engineering

Water Control System in a Building

A quarterly project Presented to the Faculty of Computer Informatics and Engineering

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Dedication

We dedicate this report to my family and many friends. A special feeling of gratitude to my loving parents, with their words of encouragement and push for tenacity ring in my ears. A special thanks and deep gratitude to the wonderful and my mother.

We also dedicate this report to my many friends who have supported me throughout the process. I will always appreciate all they have done for helping me develop my technology skills and for the many hours of proofreading, and for helping me to master the leader dots.

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We would like to acknowledge and thank my school division for allowing me to conduct my research and providing any assistance requested. Special thanks goes to the members of staff development and human resources department for their continued support. Special thanks to Deanship of the Faculty of Computer Engineering and Informatics in the Syrian private university

Finally we would like to thank the beginning teachers, mentor-teachers and administrators in our school division that assisted me with this project. Their excitement and willingness to provide feedback made the completion of this research an enjoyable experience.

Abstract

In water industry, the water is stored in OHT (Over Head Tank). This is located so far from the WTP (Water Treatment Plant) .This also not so convenience to the user to look after the tank, in order to control the level of the water in the tank.

To start managing the water flow, there is a need to understand the entire system that consists of two tanks; the first one receives the water from a pump feeding the second tank by a valve making the both tanks in interacting mode.

To design a control system that controls the level in both tanks, we have to start by modeling, analyzing our model then think about the control type to such system.

The analysis and modeling of such system has been made with the aid of Matlab and Simulink to analyze the level of water in the two tanks, the required specification has been achieved and the results is quite suitable to start the design part as a future suggested work.

The aim of this project is to control and manage water flow in a building. This building could be a Hospital or Hotel or normal building with many floors and apartments as areal practical application..To start managing the water flow, there is a need to understand the entire system that consists of two tanks, the first one receives the water from a pump feeding the second tank by a valve making the both tanks in interacting mode.

To design a control system that controls the level in both tanks , we have to start by modeling , analyzing our model then think about the control type to such system.

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Chapter 1

Introduction Control Systems

Introduction

1.1 A control system:

Consisting of interconnected components is designed to achieve a desired purpose. To understand the purpose of a control system, it is useful to examine examples of control systems through the course of history. These early systems incorporated many of the same ideas of feedback that are in use today.

1.2 Modern control:

Engineering practice includes the use of control design strategies for improving manufacturing processes, the efficiency of energy use, advanced automobile control, including rapid transit, among others.

We also discuss the notion of a design gap. The gap exists between the complex physical system under investigation and the model used in the control system synthesis.

The iterative nature of design allows us to handle the design gap effectively while accomplishing necessary tradeoffs in complexity, performance, and cost in order to meet the design specifications.

I.3 Definitions

1.3.1 System:

A system is an interconnection of elements and devices for a desired purpose.

1.3.2 Control System:

An interconnection of components forming a system configuration that will provide a desired response, The basis for analysis of a system is the foundation provided by linear system theory, which assumes a cause effect relationship for the components of a system. Therefore a component or process to be controlled can be represented by a block.

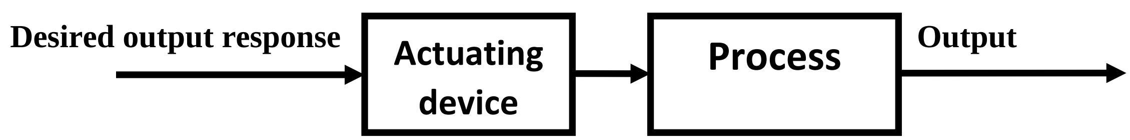
1.3.3 Process:

The process is the device, plant, or system under control. The input and output relationship represents the cause-and-effect relationship of the process, which in turn represents a processing of the input signal to provide an output signal variable, often with a power amplification. An open-loop control system utilizes a controller or control actuator to obtain the desired response

Figure (1.1), Process to be controlled

1.3.4 Open-Loop Control Systems

Open loop control system utilize a controller or control actuator to obtain the desired response as in figure (1.2).



Figure(1.2), Open-loop control system (without feedback)

1.3.5 Closed-Loop Control Systems

Closed loop system utilizes feedback to compare the actual output to the desired output response in SISO system shown in figure(1.3), as well as in MIMO system shown in figure (1.4).

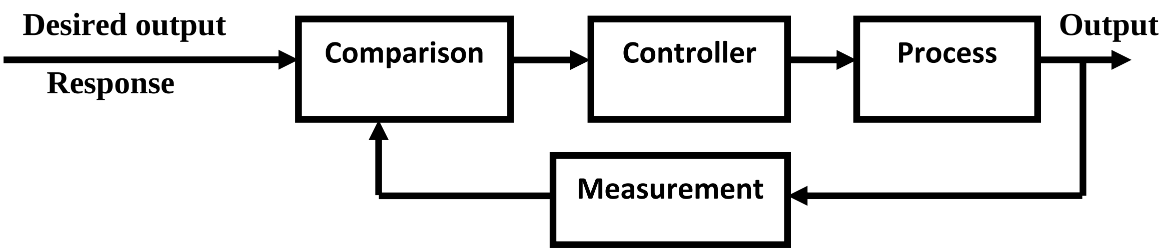


Figure (1.3), Closed-loop feedback control system(with feedback)

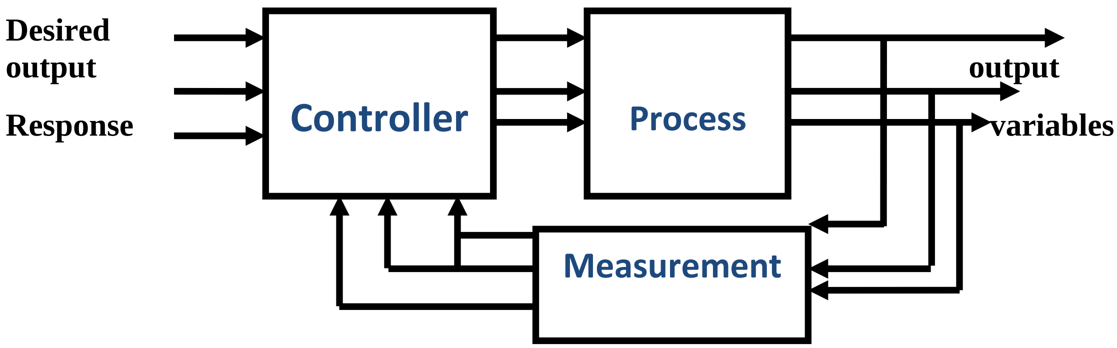


Figure (1.4), Multivariable Control System

1.4 What is Feedback?

The term feedback is used to refer to a situation in which two (or more) dynamical systems are connected together such that each system influences the other and their dynamics are thus strongly coupled.
By dynamical system, we refer to a system whose behavior changes over time, often in response to external stimulation or forcing.
Simple causal reasoning about a feedback system is difficult because the first system influences the second and the second system influences the first, leading to a circular argument.
This makes reasoning based on cause and effect tricky and it is necessary to analyze the system as a whole.
A consequence of this is that the behavior of feedback systems is often counterintuitive and it is therefore necessary to resort to formal methods to understand them.

Chapter 2

Response of Control System

2.1 Time response (Transient and steady state Responses):

The time response of a control system consists of two parts: the transient response and the steady-state response.

Transient response (t_r), we mean that which goes from the initial state to the final state.

Steady-state response (ss), we mean the manner in which the system output behaves as t approaches infinity. Thus the system response c(t) may be written as:

$$C(t) = C_{tr}(t) + C_{ss}(t)$$

The output response of a system is the sum of two responses: the forced response and the natural response.

Steady state occurs after the system becomes settled and at the steady system starts working normally. Steady state response of control system is a function of input signal and it is also called as forced response.

Now the transient state response of Control System gives a clear description of how the system functions during transient state and steady state response of control system gives a clear description of how the system functions during steady state. Therefore the time analysis of both states is very essential. We will separately analyze both the types of responses. Let us first analyze the transient response. In order to analyze the transient response, we have some time specifications and they are written as follows: Delay Time : This time is represented by t_d. The time required by the response to reach fifty percent of the final value for the first time, this time is known as delay time. Delay time is clearly shown in the time response specification curve.

2.2 Transient Response specifications :

Transient response specification are as shown :

Rise Time : This time is represented by t_r . We define rise time in two cases:

1. **In case of under damped systems where the value of ζ is less than one, in this case rise time is defined as the time required by the response to reach from zero value to hundred percent value of final value.**
2. **In case of over damped systems where the value of ζ is greater than one, in this case rise time is defined as the time required by the response to reach from ten percent value to ninety percent value of final value.**

Peak Time : This time is represented by t_p. The time required by the response to reach the peak value for the first time, this time is known as peak time. Peak time is clearly shown in the time response specification curve.

Settling Time : This time is represented by time.

The time required by the response to reach and within the specified range of about (two percent to five percent) of its final value for the first time, this time is known as settling time. Settling time is clearly shown in the time response specification curve.

Maximum Overshoot : It is expressed (in general) in percentage of the steady state value and it is defined as the maximum positive deviation of the response from its desired value. Here desired value is steady state value.

Steady State Error: It can be defined as the difference between the actual output and the desired output as time tends to infinity.

Now we are in position we to do a time response analysis of a first order system.

2.3 Transient State and Steady State Response of First Order Control System

Let us consider the block diagram of the first order system shown in figure (2.1),

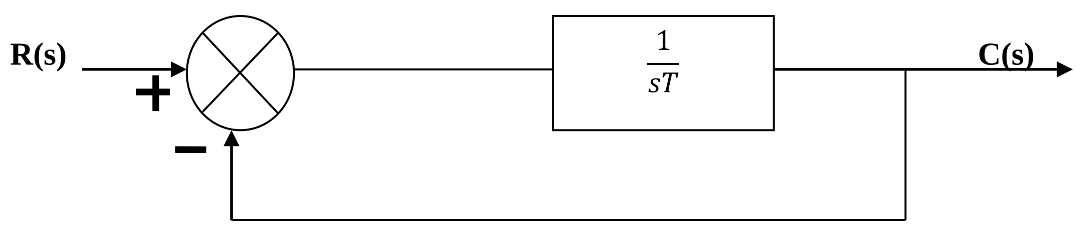


Figure (2.1), Closed loop first order system

From this block diagram shown in figure(2.1), we can find overall transfer function which is linear in nature. The transfer function of the first order system is 1/((sT+1)) . We are going to analyze the steady state and transient response of Control System for the following standard signal.

1. **Unit impulse.**
2. **Unit step.**
3. **Unit ramp.**

2.3.1 Unit impulse response:

We have Laplace transform of the unit impulse is 1. Now let us give this standard input to a first order system, we have

$$C(s) = \frac{1}{1 + sT}$$

Now taking the inverse Laplace transform of the above equation, we have

$$C(t) = e^{-t/T} / T$$

It is clear that the steady state response of control system depends only on the time constant 'T' and it is decaying in nature.

2.3.2 Unit step response:

We have Laplace transform of the unit impulse is 1/s. Now let us give this standard input to first order system, we have

$$C(s) = \frac{1}{s(1 + sT)}$$

With the help of partial fraction, taking the inverse Laplace transform of the above equation, we have

$$C(t) = 1 - e^{-t/T}$$

It is clear that the time response depends only on the time constant 'T'. In this case the steady state error is zero by putting the limit t is tending to zero. The transient response of the first order system to a unit step input is shown in figure (2.2).

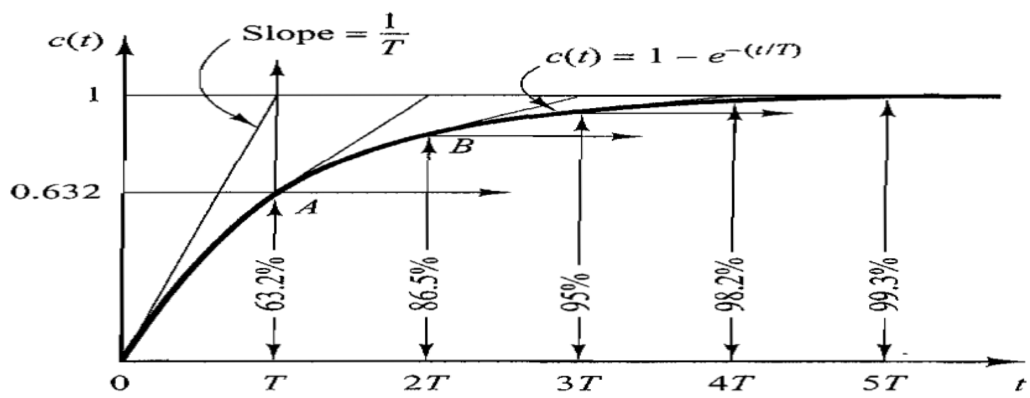


Figure (2.2), step response of first order system

One important characteristic of such an exponential response curve c(t) is that at t = T the value of c(t) is 0.632,

$$c\,(T) = 1 - e^{-1} = 0.632$$

We now define three transient response performance specifications

Time constant T: the time constant can be described as the time for $e^{-1} = 0.37$, to decay to 37% of its initial value. The time constant is the time it takes for the step response to rise to 63% of its final value..

Rise Time, *Tr Rise time* is defined as the time for the waveform to go from 0.1 to 0.9 of its final value. Rise time is found by solving c(t) for the difference in time at *c(t)* = 0.9 and *c(t)* = 0.1. Hence,

$$T_r = 2.31\,T - 0.11\,T = 2.2\,T$$

Settling Time ,*Ts, Settling time* is defined as the time for the response to reach, and stay within, 2% of or 5% of its final value.

For 2%, if we let *c(t)* = 0.98 and solving for time, *t,* we find the settling time to be

$$T_S = 4\,T$$

2.3.3 Unit ramp response:

We have Laplace transform of the unit impulse is $1/s^2$. Now let us give this standard input to first order system, we have

$$C(s) = \frac{1}{s^2(1 + sT)}$$

With the help of partial fraction, taking the inverse Laplace transform of the above equation we have

$$C(t) = 1 - T + Te^{-t/T}$$

On plotting the exponential function of time we have 'T' by putting the limit t is tending to zero.

2.4 Transient State and Steady State Response of Second Order Control System

Let us consider the block diagram of the second order system in figure (2.3).

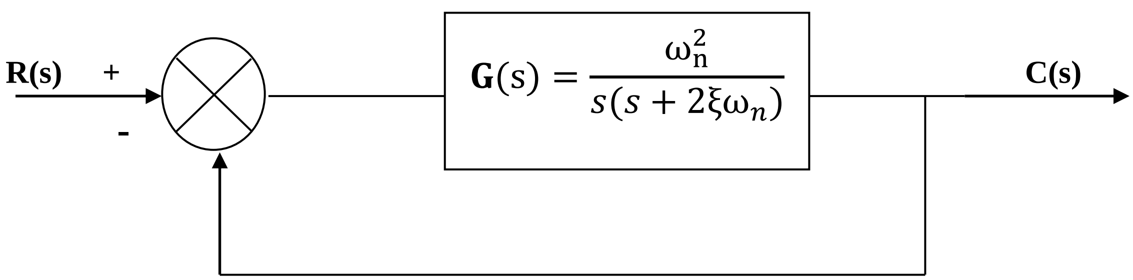


Figure (2.3), Closed loop of standard second order system

From this block diagram we can find overall transfer function which is nonlinear in nature. The transfer function of the second order system is

$(\omega^2) / (s (s + 2\zeta\omega))$.

We are going to analyze the transient state response of control system for the following standard signal.

2.4.1 Unit impulse response:

We have Laplace transform of the unit impulse is 1. Now let us give this standard input to second order system, we have

$$C\,(s) = \frac{\omega^2}{s(s + 2\omega\zeta)}$$

Where ω is natural frequency in rad/sec and ζ is damping ratio.
For several types of input the transient response is determined as shown:

2.4.2 Unit step response:

The Laplace transform of the unit impulse is 1/s. Now let us give this standard input to first order system, we have

$$C\,(s) = \frac{\omega^2}{s(s + 2\omega\zeta)}$$

With the help of partial fraction, taking the inverse Laplace transform of the above equation we have

$$C\,(t) = 1 - \frac{e^{-\zeta\omega t}\sin\left[\omega\sqrt{1-\zeta^2 t} + \tan^{-1}\frac{\sqrt{1-\zeta^2}}{\zeta}\right]}{\sqrt{1-\zeta^2}}$$

Now we will see the effect of different values of ζ on the response. We have three types of systems on the basis of different values of ζ.

1. **Under damped system : A system is said to be under damped system when the value of ζ is less than one. In this case roots are complex in nature and the real parts are always negative. System is asymptotically stable. Rise time is lesser than the other system with the presence of finite overshoot.**
2. **Critically damped system : A system is said to be critically damped system when the value of ζ is one. In this case roots are real in nature and the real parts are always repetitive in nature. System is asymptotically stable. Rise time is less in this system and there is no presence of finite overshoot.**
3. **Over damped system : A system is said to be over damped system when the value of ζ is greater than one. In this case roots are real and distinct in nature and the real parts are always negative. System is asymptotically stable. Rise time is greater than the other system and there is no presence of finite overshoot.**
4. **Sustained Oscillations : A system is said to be sustain damped system when the value of zeta is zero. No damping occurs in this case.**

Step response of different values of ζ are shown in figure (2.4).

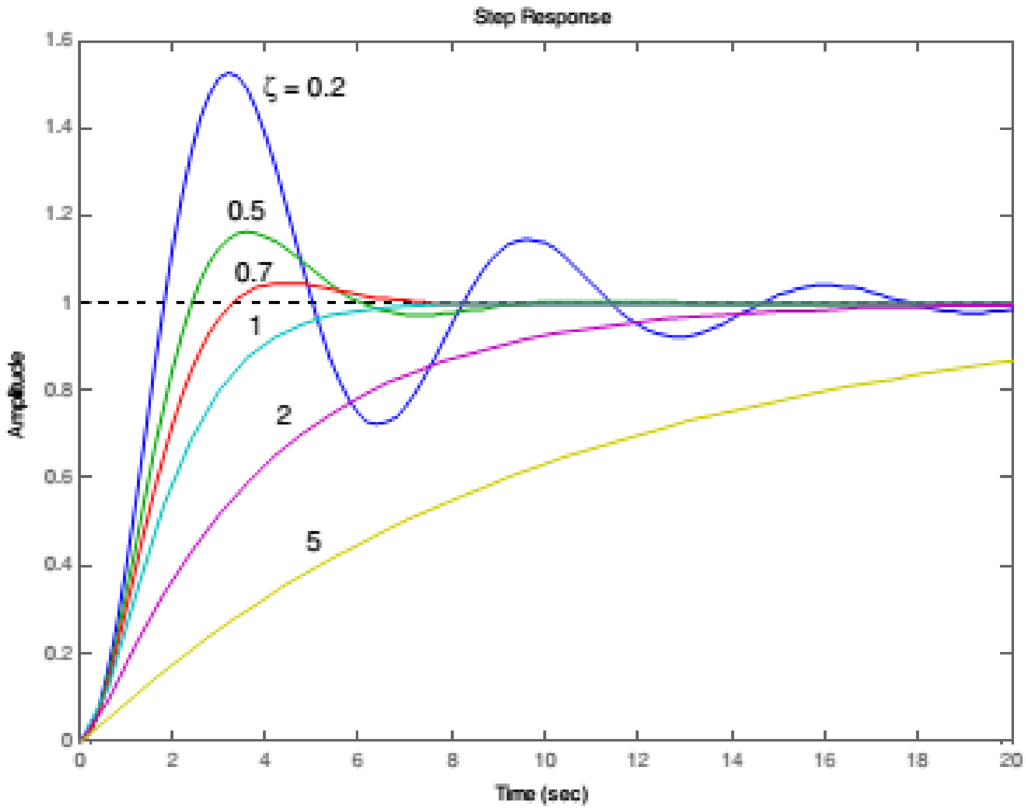


Figure (2.4), step response for different ζ

Now let us derive the expressions for rise time, peak time, maximum overshoot, settling time and steady state error with a unit step input for second order system.

2.4.2.1 Rise time:

In order to derive the expression for the rise time we have to equate the expression for c(t) = 1. From the above we have

$$C(t) = 1 = 1 - \frac{e^{-\zeta\omega t}\sin\left[\omega\sqrt{1-\zeta^2}t + \tan^{-1}\frac{\sqrt{1-\zeta^2}}{\zeta}\right]}{\sqrt{1-\zeta^2}}$$

On solving above equation we have expression for rise time equal to

$$t_r = \frac{\pi - \tan^{-1}\frac{\sqrt{1-\zeta^2}}{\zeta}}{\omega\sqrt{1-\zeta^2}}$$

2.4.2.2 Peak Time:

On differentiating the expression of c(t) we can obtain the expression for peak time. dc(t) / dt = 0 we have expression for peak time,

$$t_p = \frac{\pi}{\omega\sqrt{1-\zeta^2}}$$

2.4.2.3 Maximum overshoot:

Now it is clear from the figure that the maximum overshoot will occur at peak time tp hence on putting the value of peak time we will get maximum overshoot as

$$\%\ MP = e^{-\zeta\pi/\sqrt{1-\zeta^2}} \times 100$$

2.4.2.4 Settling Time:

Settling time is given by the expression

$$t_s = \frac{4}{\omega\zeta}$$

2.4.2.5 Steady state error :

The steady state error is difference between the actual output and the desired output hence at time tending to infinity the steady state error is zero.

All the above performance specifications are shown in figure (2.5).

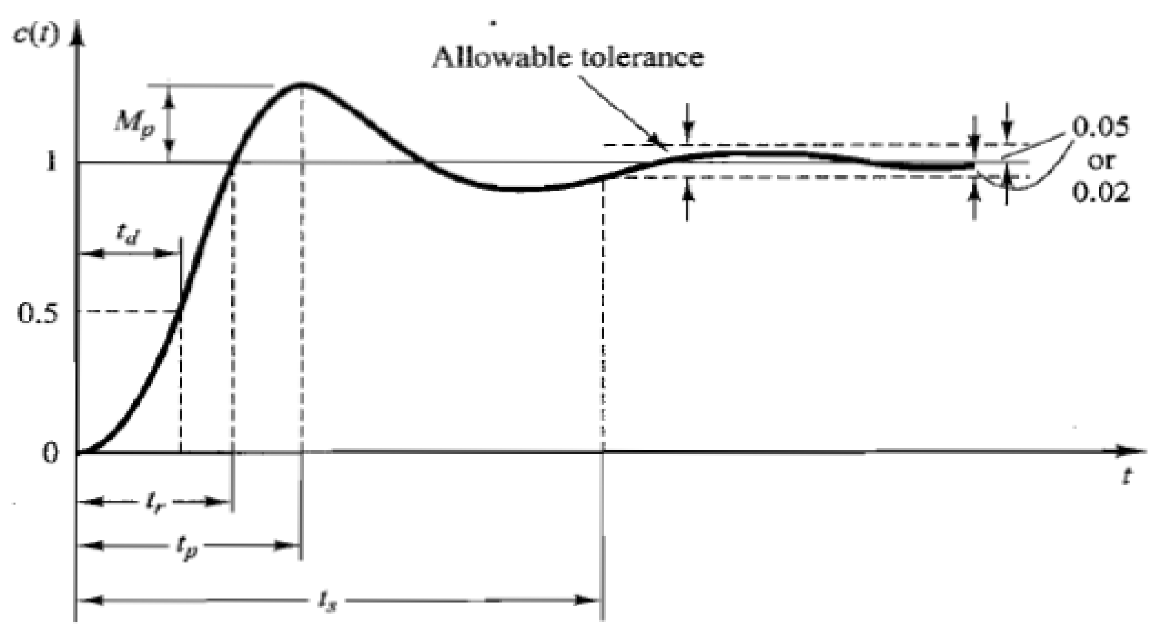


Figure (2.5), step response specifications of second order system

2.5 The Control Process

It is the job of a control engineer to analyze existing systems, and to design new systems to meet specific needs. Sometimes new systems need to be designed, but more frequently a controller unit needs to be designed to improve the performance of existing systems. When designing a system, or implementing a controller to augment an existing system, we need to follow some basic steps:

2.5.1 Model the system mathematically.

Mathematical models of control systems are mathematical expressions which describe the relationships among system inputs, outputs and other inner variables.

Establishing the mathematical model describing the control system is the foundation for analysis and design of control systems.

Systems can be described by differential equations including mechanical systems, electrical systems, thermodynamic systems, hydraulic systems or chemical systems etc.

The response to the input (the output of the system) can be obtained by solving the differential equations, and then the characteristic of the system can be analyzed.

The mathematical model should reflect the dynamics of a control system and be suitable for analysis of the system.

Thus ,when we construct the model, we should simplify the problem to obtain the approximate model which satisfies the requirements of accuracy.

Mathematical models of control systems can be established by theoretical analysis or practical experiments.

The theoretical analysis method is to analyze the system according to physics or chemistry rules (such as Kirchhoff's voltage laws for electrical systems, Newton's laws for mechanical systems and Law of Thermodynamics).

The experimental method is to approximate the system by the mathematical model according to the outputs of certain test input signals, which is also called system identification.

System identification has been developed into an independent subject.

In this chapter, the theoretical analysis method is mainly used to establish the mathematical models of control system.

There are a number of forms for mathematical models, for example, the differential equations, difference equations and state equations in time domain, the transfer functions and block diagram models in the complex domain, and the frequency characteristics in the frequency domain.

In this chapter, we shall study the differential equation, transfer function and block diagram formulations.

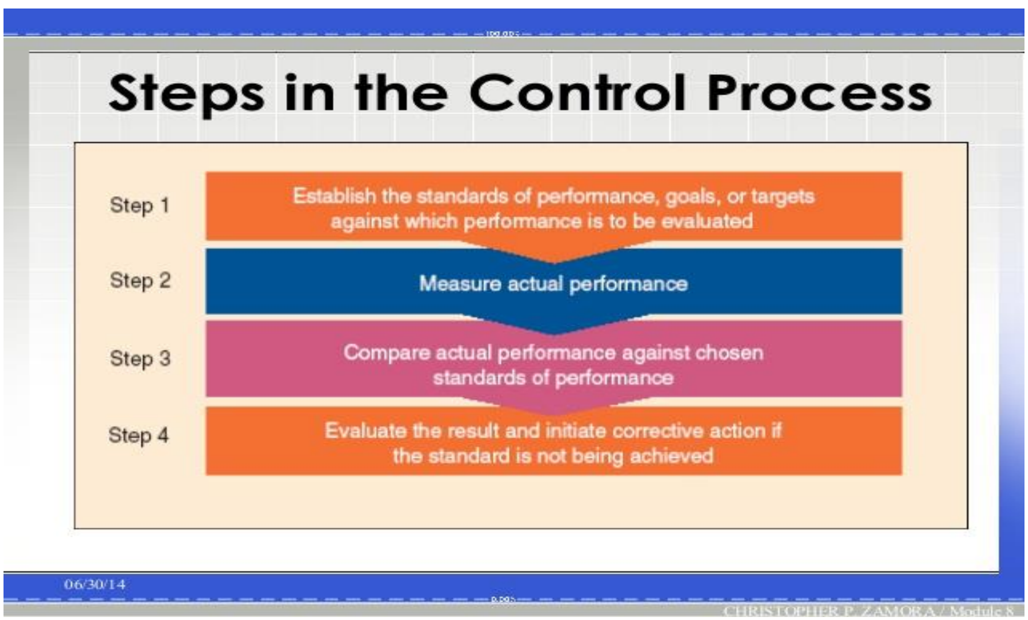
2.5.2 Analyze the mathematical model.

The analysis part concerning the study of performance requirements of transient response as well as the steady state error .when this analysis is done the controller design can be chosen to satisfy our performance of the plant or process.

2.5.3 Design system/controller.

After the analysis part is done, one can specify the type of controller that can satisfy the performance requirements of the plant.

2.5.4 Implement system/ controller and test



Chapter 3

Modeling of two tank system

3.1 Introduction

The fluid flow system are very common in the process control .It can be modeled by using generalized definition and modeling of hydraulic system [7]. In this, Matlab and Simulink is used to model the two tank system with interacting between them.

3.2 Modeling of single tank system

For a single tank liquid level system is illustrated in figure (3.1). It must be known that, how to simplify the design in the equation. This type of the system consists of source inflow rate qi into the tank. A drain valve in this to regulate the water out flow rate (qo):

For the liquid level system in figure (3.1). It can be obtained a Mathematical Model to get the relationship between qi and qo or between qi and H.[8].

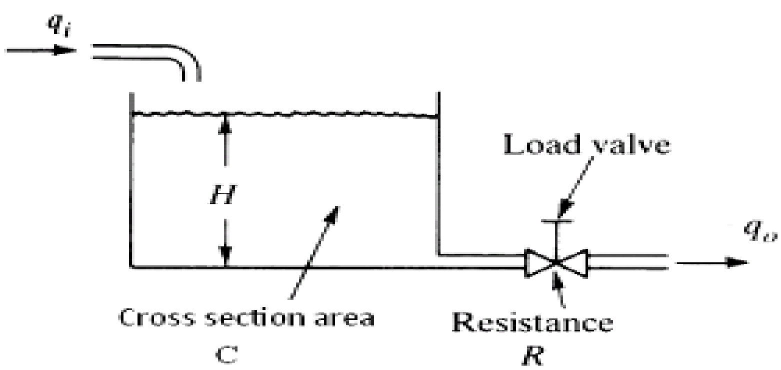


Figure (3.1), Single tank liquid level system

The flow resistance can be determined by the following relationship:

$$R = \frac{Change\ in\ level}{Change\ in\ the\ flow\ rate} \quad [3\text{-}1]$$

$$R = \frac{dh}{dq} \quad [3\text{-}2]$$

in the steady state , It will use this equation

$$R = \frac{H}{Q} \quad is\ a\ linear\ equation \quad [3\text{-}3]$$

The system is modeled by using physical principles .The physical equation governing theaccumulation water in the tank (ACC) or change in liquid store [3, 9].

Accumulation water in the tank (ACC) = input - output

$$\boldsymbol{Cross\ section\ area\ (C) = \frac{Accumulation\ water\ in\ tank}{Change\ in\ the\ hieght}} \quad [3\text{-}4]$$

$$\boldsymbol{C = \frac{Acc}{\frac{dh}{dt}} \quad \rightarrow \quad Acc = C\ \frac{dh}{dt}} \quad [3\text{-}5]$$

C is constant

So that .Applied the balance equation

$$\boldsymbol{Acc = in - out = C\ \frac{dh}{dt}} \quad [3\text{-}6]$$

Then

$$\boldsymbol{q_{in} - q_{out} = C\frac{dh}{dt}} \quad [3\text{-}7]$$

$$\boldsymbol{q_{out} = \frac{h}{R}} \quad [3\text{-}8]$$

And

$$\boldsymbol{RC\frac{dh}{dt} + h = R\ q_{in}} \quad [3\text{-}9]$$

Now, taking the laplace and asuuming that the Tf is relating Qin as input and H as output

$$\boldsymbol{\frac{H(s)}{Q(s)} = \frac{1}{RC\ s+1}} \quad [3\text{-}10]$$

Which is a first order system, that is always stable.

3.3 Modeling of Two tank system

Now design a hydraulic system with two tanks as interaction network and use this equation in the two tanks .It consists of source, two tanks and pipe between them. q may represent a water from motor to tank 1 as show in figure (3.3) :

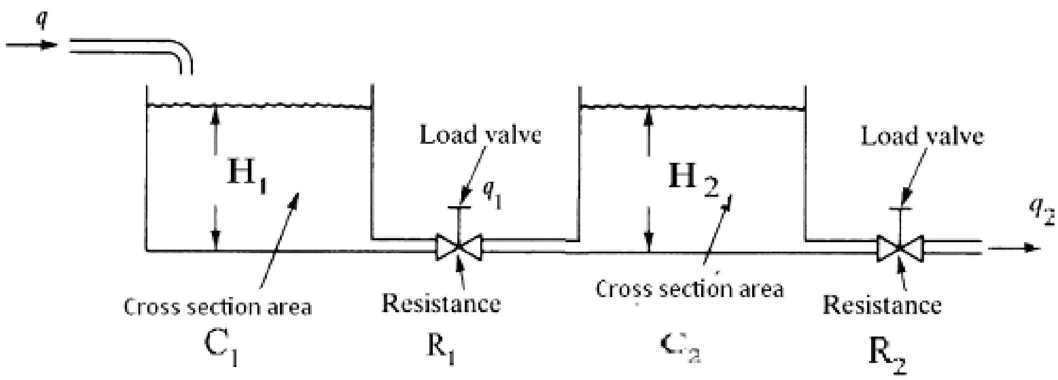


Figure (3.3), Liquid system in the two tanks as interaction network

Where:

q: input flow rate to tank1

q1: output flow rate from tank 1

q2: output flow rate from tank 2

H1: water level in tank1

H2: water level in tank1

R1: Resistivity in valve 1

R2: Resistivity in valve 2

C1: cross section area in tank 1

C2: cross section area in tank 2

In the tank 1

From fig (3.3), the accumulation water in tank 1(Acc1) is the difference between the input flow rate to tank1 (q) and output flow rate from tank 1 (q1)

$$Acc_1 = In - Out = q - q_1 \quad \textbf{[3-11]}$$

$$R = \frac{Change\ in\ level}{Change\ in\ the\ flow\ rate} \quad \textbf{[3-12]}$$

In the steady state

$$R_1 = \frac{h_1 - h_2}{q_1} \rightarrow q_1 = \frac{h_1 - h_2}{R_1} \quad \textbf{[3-13]}$$

The Laplace domain can be used to solve this equation:

$$Q_1(s) = \frac{H_1(s) - H_2(s)}{R_1} \quad \textbf{[3-14]}$$

Modeling of system requires us to determine the relationship between (h1 -h2) and divided by R1as show in the block diagram figure (3.4):

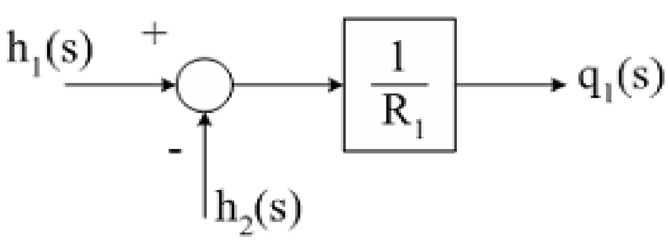


Figure (3.4), relating R and H

Since that

$$Cross\ section\ area\ (C) = \frac{Accumulation\ water\ in\ tank}{Change\ in\ the\ hieght}$$

From equation 3-7, then

$$q - q_1 = C_1 \frac{dh_1}{dt} \qquad [3\text{-}15]$$

Take Laplace domain yield

$$Q(s) - Q_1(s) = C_1\ s\, H_1 \qquad [3\text{-}16]$$

$$H_1(s) = \frac{Q(s) - Q_1(s)}{C_1\ s} \qquad [3\text{-}17]$$

From the previous equation draw the second block diagram by subtract Q Q1 and divided by C1S as shown in figure (3.5).

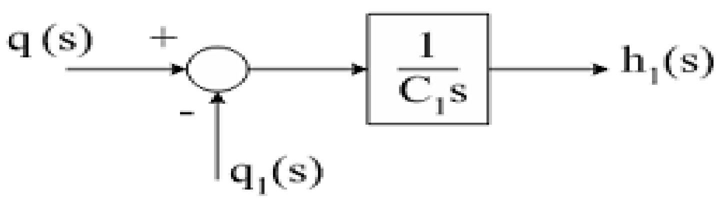


Figure (3.5), modeling of the first tank

Where the liquid inflow q(s) and q1 as the flow out from tank1 to tank2.

In tank2

$$R_2 = \frac{dh_2}{dq_2}\ , \quad in\ steady\ state, we\ have$$

$$R_2 = \frac{H_2}{Q_2} \qquad [3\text{-}18]$$

The third block diagram from dividing H2 by R2 From fig(3.3), the accumulation water in tank 2 is the difference between the input flow rate to tank 2(q1) and output flow rate from tank 2 (q2)-Acc2 (accumulation water in tank 2) = in- Out = q1-q2

Cross section area of tank 2

$$C_2 = \frac{Acc_2}{\frac{dh_2}{dt}} \rightarrow \quad Acc_2 = C_2 \frac{dh_2}{dt} \qquad [3\text{-}19]$$

In Laplace domain Acc2=C2SH2 .Applying these equations obtain

$$Q_1(s) - Q_2(s) = C_2\, s\, H_2(s) \qquad [3\text{-}20]$$

$$H_2(s) = \frac{Q_1(s) - Q_2(s)}{C_2\, s} \qquad [3\text{-}21]$$

This equation can be modeled by block diagramby subtract Q1(S) Q2(S) = and divided by C2sand yield h2(s) as o/p as shown in figure (3.6)

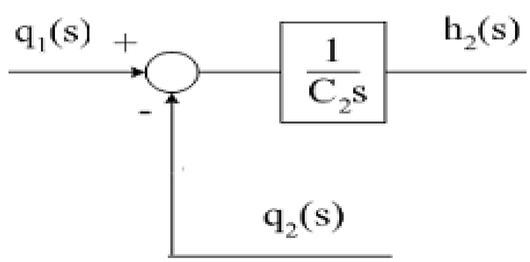


Figure (3.6), relating flow with h2

It can obtain the produce block diagram by getting the component block diagram from the previous shape, and putting all form pieces to make the final block as show in figure (3.7) Diagram. It must determine what the input and output for the block It can obtain the produce block diagram by getting the component block diagram from the previous shape, and putting all form pieces to make the final block as show in figure (3.7) Diagram. It must determine what the input and output for the block

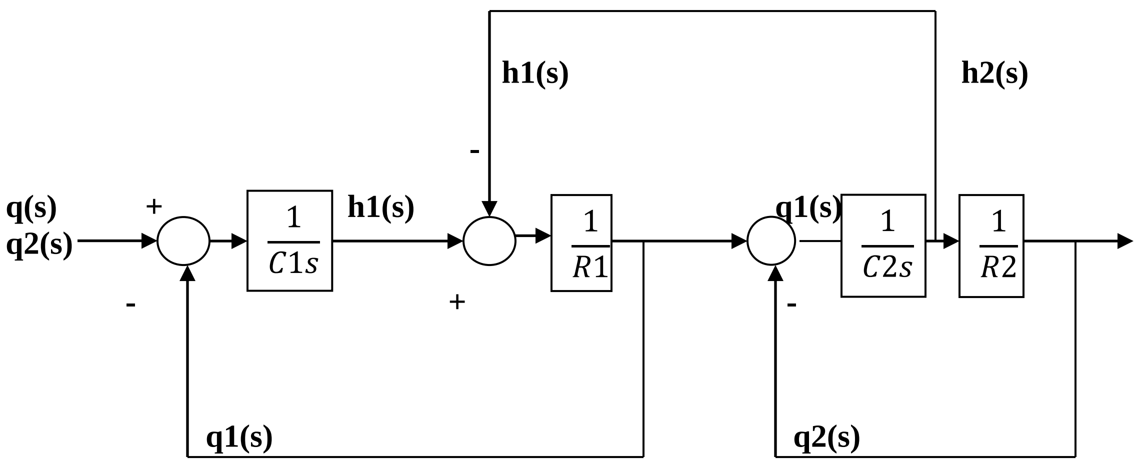


Figure (3.7), Final Block Diagram

By using the simplifications rule of Block diagrams, figure (3.7) can be simplified as shown in figure (3.7.a)

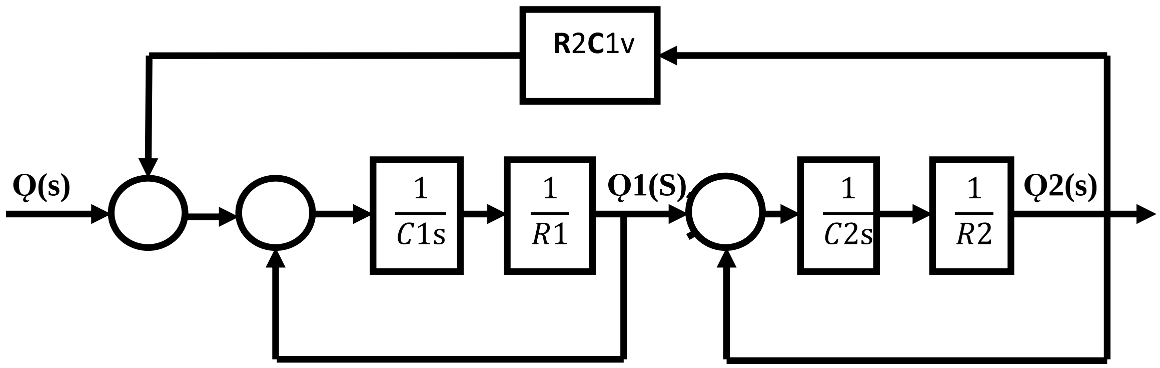


Figure (3.7.a),simplification of figure(3.7)

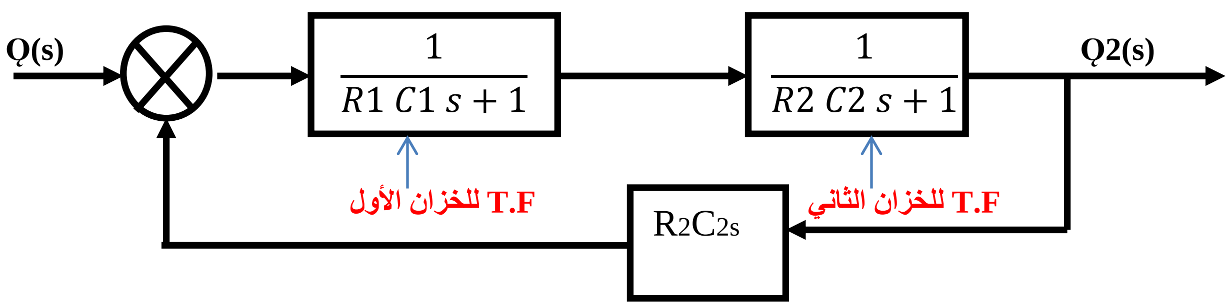


Figure (3.7.b), simplification of figure(3.7.a)

Final transfer function that relates Q out to Q in is shown in figure (3.7.c)

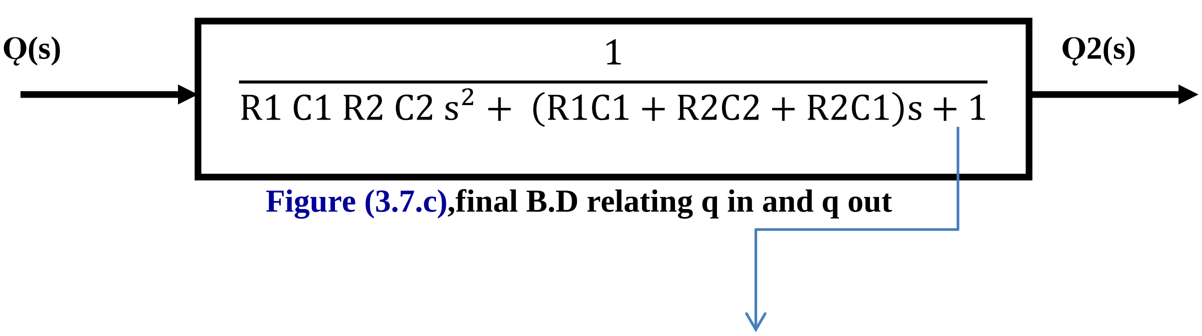


Figure (3.7.c),final B.D relating q in and q out

Overdamped stable

3.5 Matlab and Simulink simulation

The model derived in the Block diagram of figure(3.7) is simulated using Simulink , before starting the simulation , some model requirements must be determined and achieved such as the used tanks and their related cross sectional area, also the resistance of the piped used must be determined as will be shown:

3.5.1 C- Cross sectional area of the tank

The tank that is proposed to be used is shown in figure (3.8)

Figure (3.8), the proposed used tank

This tank has the following specifications:

PolyEthylene

Three layer

White Outlier to reflex sunshine

As much as it can

Black middle layer with 2% Carbon

To absorptive beam with high frequency

White smooth inside layer to prevent

Grows of moss or bacteria

Capacity:10000 L

Height: 317 Cm

Diameter: 210 Cm

Since that the diameter of the tank is 210 Cm or (2.10 meter) , then the cross sectional are can be determined as:

$$C_1 = C_2 = \frac{\pi}{4}(2.1)^2$$

$$C_1 = C_2 = 3.4636\ m^2$$

3.5.2 Q Flow rate

The flow-in rate is defined in the specification of the proposed pump that is being used. This pump is shown in figure (3.9)

Figure(3.9), Main water source pump

Model : ClaytechInox 240

Max Pressure: 350KPa (50 psi) (kpa:kilo Pascal)

Includes hydrotronic switch to avoid motor burnout.

Power Absorbed: 1000 watt.

Volt: 240v   (3-fas)

Max Head: 48m.

Max Flow Rate: 100 Liters per minute.

Stages:.3

Inlet Size: 25.4 mm (1 inch).

Outlet Size: 25.4 mm (1 inch).

Weight (kg): 12kg.

Thus the flow rate Q1 and Q2 is 100 L/minute.

To convert it to meter then Q = 100/1000 = 0.1 m^3/minute

To convert it to second Q = 0.1/60 = 0.001666666 m^3/second.

3.5.3 R calculations

The R is defined according to equations [3-9] and [3-14] .

In most literatures, this value is assumed to be constant depend on each applications. This value can be produced as the change in level difference /change in flow rate, and may be considered constant as R1 = R2 = R [7]

We have tested several values of R to test its effect on the step response modeled in figure (3.10) shown below

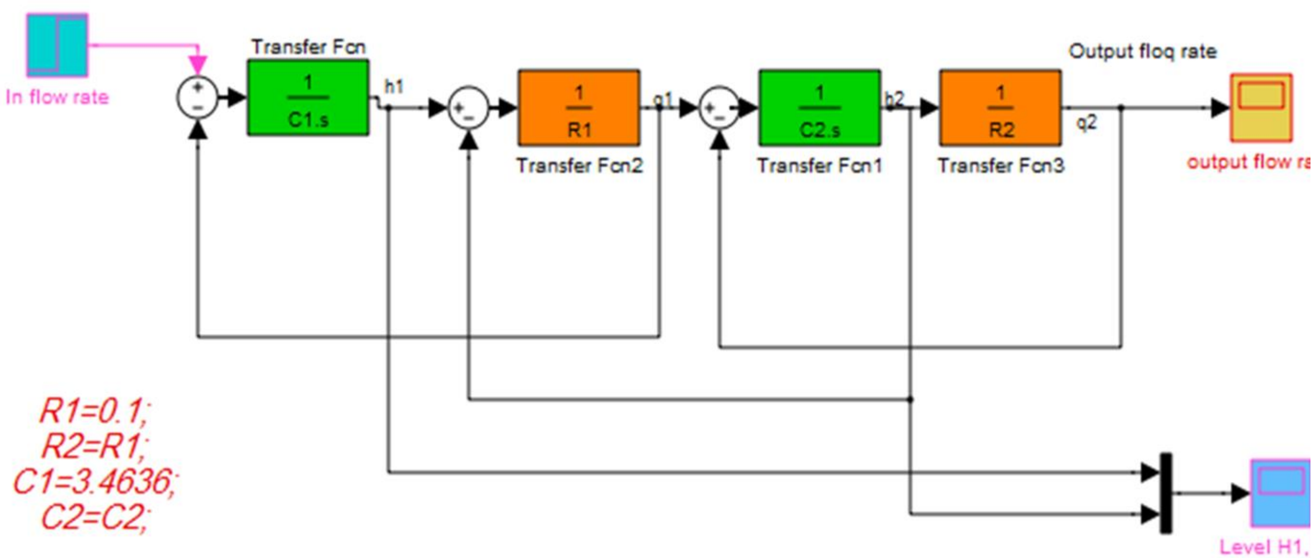


Figure (3.10), The Simulink model of two interacting tank system

Starting with R = 0.5 the simulation results is shown in figure (3.11)

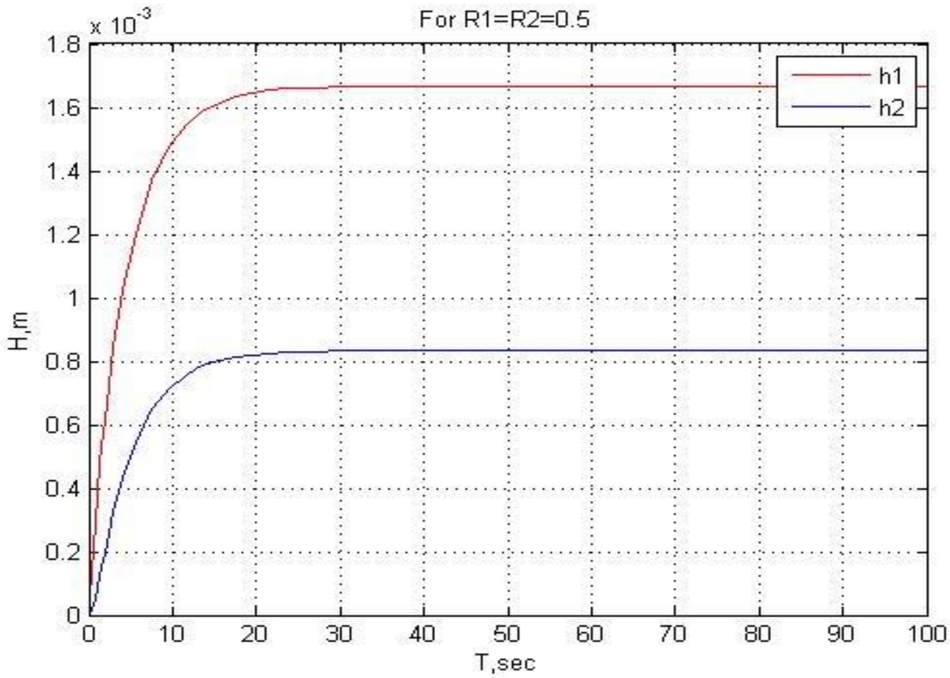


Figure (3.11), response of the levels in both tanks when R=0.5

the level h1 and h2 are both stable. Taking another value say R=1, the output response id shown in figure (3.12)

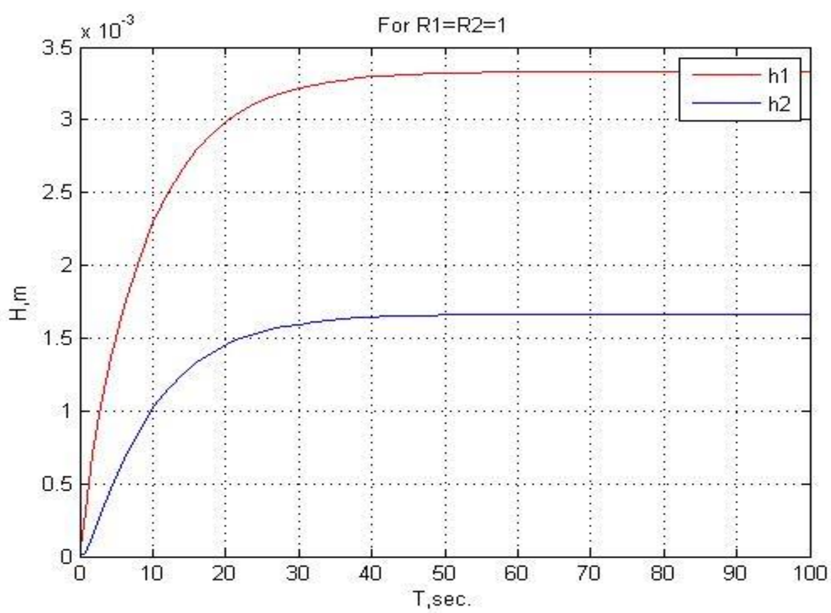


Figure (3.12), response of the levels in both tanks when R=1

For R=10, the results shown in figure (3.13)

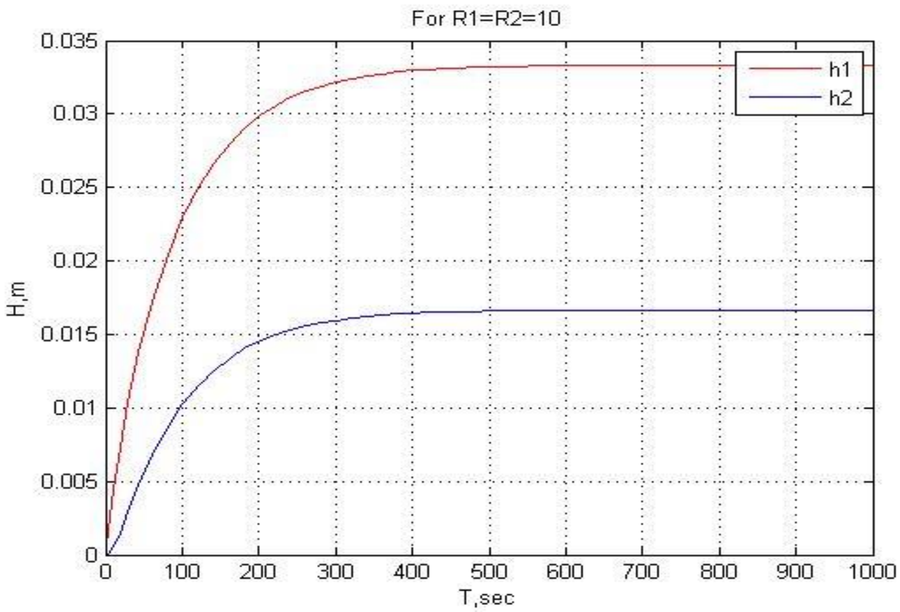


Figure (3.13), response of the levels in both tanks when R=10

For R=50 the results was as shown in figure (3.14)

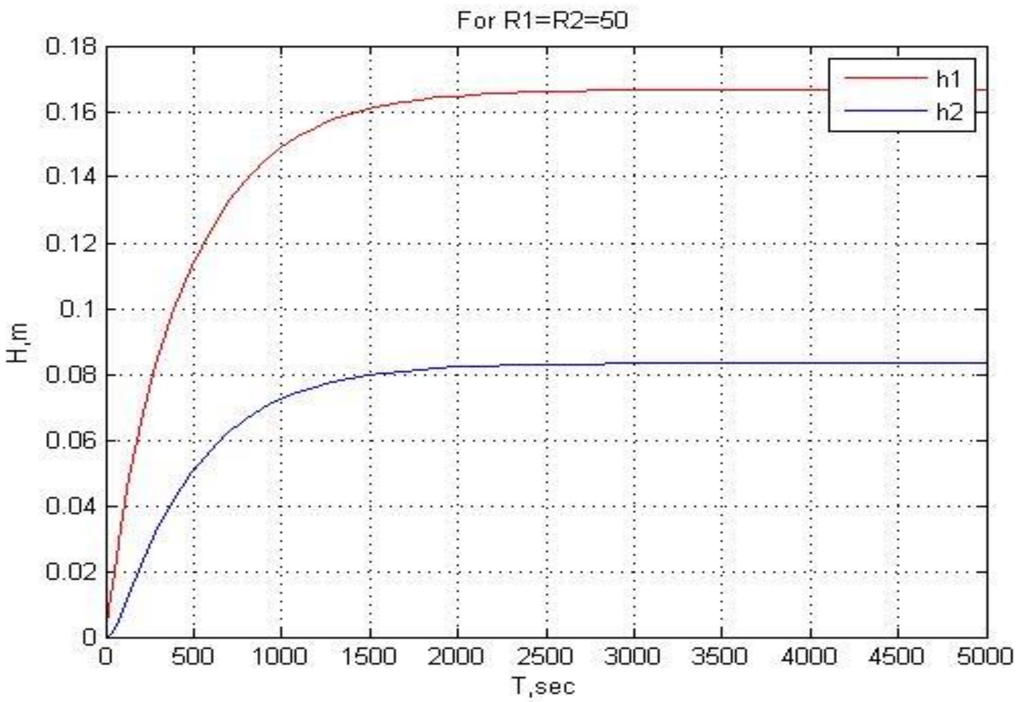


Figure (3.14), response of the levels in both tanks when R=50

The last tested value was taken to be 100 and the simulated results is shown in figure (3.15)

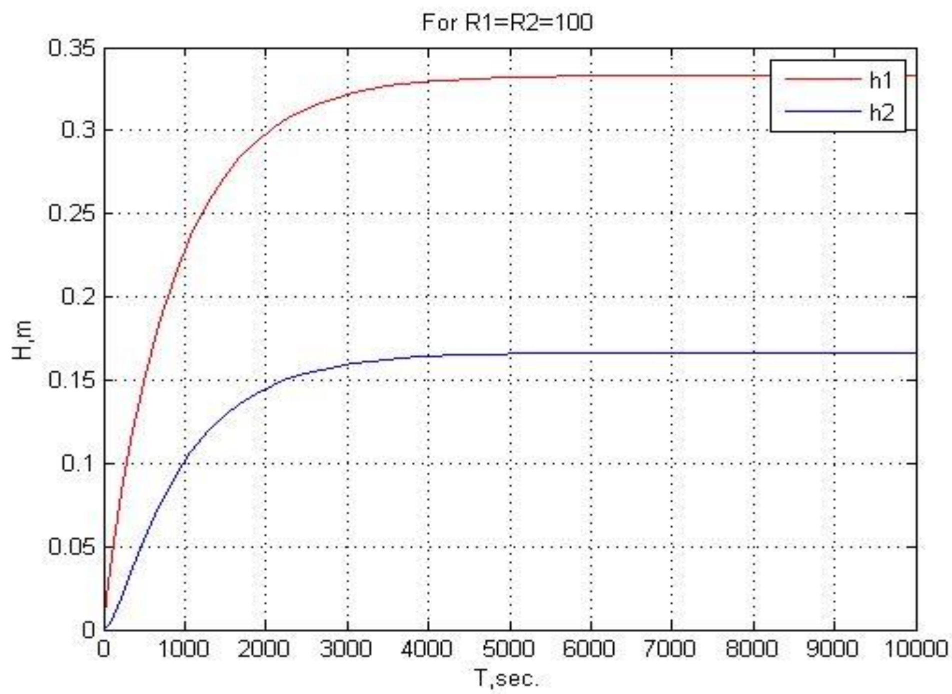


Figure (3.15), response of the levels in both tanks when R=100

In all of these cases, the response is stable , its still first order stable response, and the effect of R shown in the speed of filling the tank and speed of response. As R increased the response become slow, and there is a need to excessed the simulation time.

Thus the proposed value that will be taken for modeling will be R1=R2=1.

3.6 Simulation and results of the outflow

After all block diagram was completed for the liquid level system. It can now be implemented this diagram and system in a simulation model. This block is used to represent the two tanks system. Matlab program was used to simulate this system . A step input in the simulink is referred to the process input as an inflow rate (qi). The simulation in the system consists of a function block of the cross section area(C) and parameter resistivity (R) in a transfer function; it can be obtained it from a block of transfer function. Scope is used to display output (q2) and scope1 to display the water level. In the two tanks (h1, h2) this figure illustrates a simulation of model of this system as shown in figure (3.10):

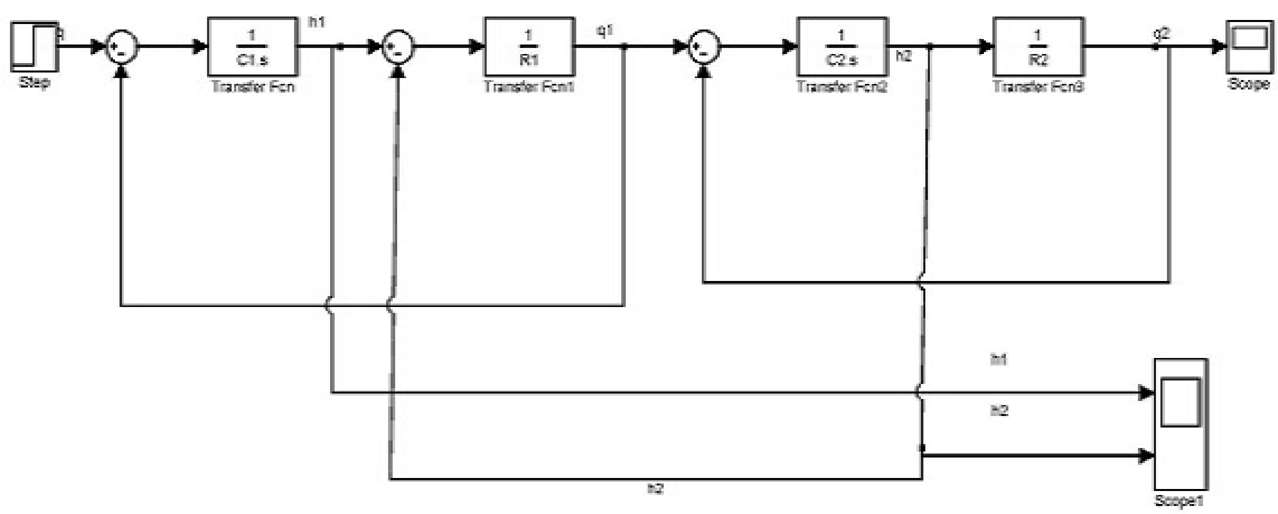


Figure (3.16), Simulink model of two interacting tank system model

The simulation results is shown below using scope1 for Qout as shown in figure (3.17) and scope2 for both H1,H2 the level in both tanks as shown in figure (3.12)

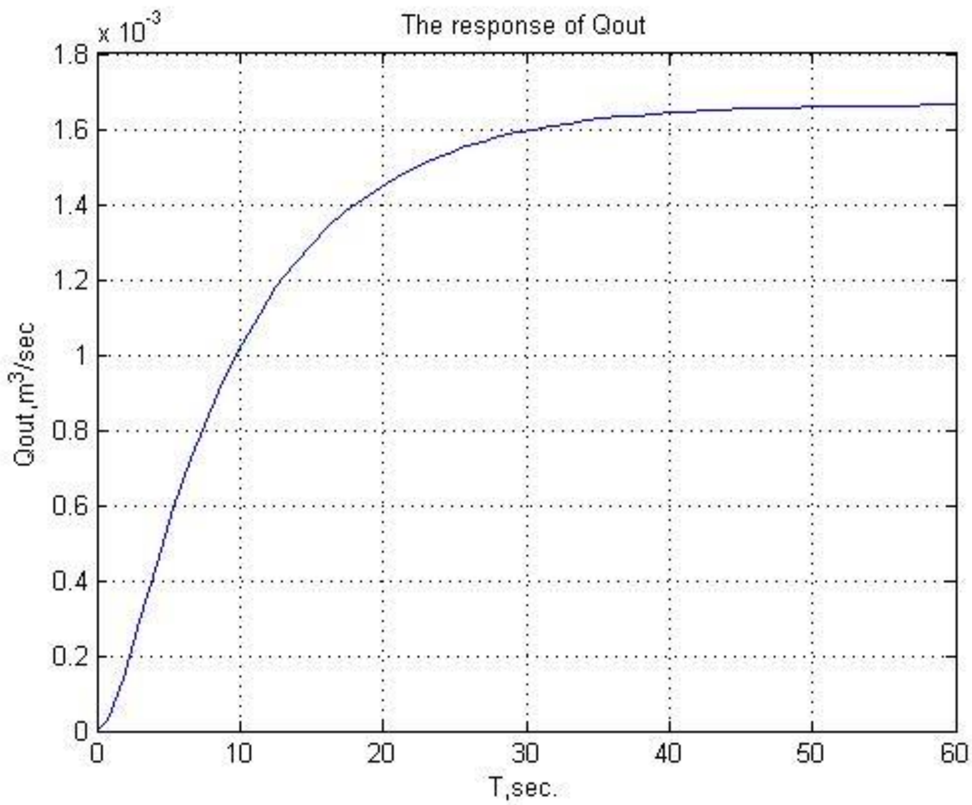


Figure (3.17), The output flow rate response

Chapter Four

Conclusion & Future works

Conclusion and Future works

4.1 Conclusion:

Using the simulation process of the two tank interacting system model , one can conclude the following:

1- **The modeling has been perform in the steady state mode, thus a linear system is produced.**
2- **The demonstrated system is simulated by the matlab and Simulink package, all the results were accurate as expected.**
3- **The level system is a stable system as shown in all results even if the risitive constant of the valve has been changed starting with R=0.5, 1,10,50,100, all these cases has been tested using Matlab and we conclude that the effect of R is on the speed of the response only and do not affect the stability requirments.**
4- **As been shown through this project that we apply some of the parts of the control strategy starting with the modeling , analysis , stability performance has been achieved, then the control algorithm can be chosen.**

4.2 Future works:

Some of the suggested future works can be:

Continue with the control strategy be defining the applied control algorithm such as:

1- **Contentious control(PID, Lead –Lag- Lead lag- Lag lead).**
2- **State space approach like pole placement.**
3- **On-Off control**
4- **Fuzzy control or other control type.**

Since that this system is stable system and the stability is satisfied and since that this is a practical implementation, we may use an On- Off control strategy with an On-Off valves.

In water industry, the water is stored in OHT (Over Head Tank). This is located so far from the WTP (Water Treatment Plant) .This also not so convenience to the user to look after the tank, in order to control the level of the water in the tank. Sometimes the user does not know the level of the tank empty, half-empty or full.

Moreover, the circuit that commonly used as an indicator circuit is so complicated to use. It contains so many components, which is sometimes can be damage when the fault happens at the circuit. By using this complicated circuit, we also have to switch on or off the pump manually. It is difficult to the human to go up to the hill (because the tank usually located at the hill) and sometimes there so difficult to trouble shoots the fault happen at the circuit.

To apply such type of control , one may use the SCADA system and PLCs as an industrial application to control the level of two interacting tank system.

References

[1] A.S. Thulkarmine, M.R.A Ghani, S.M. Amin and A.Wahab, Self-tuning Controllers for a Coupled Tank Pilot Plant: Evaluation and Comparison , IEEE, pp. 580-581, 1993.

[2] V. Ramakrishnan, Y. Zhuang, S.Y. Hu,J.P.Chen,C.C.Ko,B.M.Chen and K.C.Tan, Development of a Web-Based Laboratory for Control Experiments on a Coupled Tank Apparatus , Proceedings of the 2000 American Control Conference,Vol. 6 pp. 4409 4413

[3] CAIRO, "Coupled-tank Liquid Level Computer-controlled Laboratory Teaching Package: Experimental and Operational (Service) Manuals", Augmented Innovation Sdn.Bhd., UniversityTechnology Malaysia.

[4] J.G. Balchen and K.J. Mumme, "Process Control Structures and Application", Vannostrand Reinhold Co., New York, 1988.

[5] G. Stepanoupoulis,"Chemical Process Control", Prentice Hall of India, NewDelhi,1990.

[6] Duane Hanselman& Bruce Littlefield,"Book:MasteringMatlab® 5",

ISBN#0-13-858366-8, Prentice-Hall,1998.

[7] Ogata, K., Modern control engineering ,4th Edition,PrenticerHallPublisher,2001.

[8] Selmer A., Goodson M., Kraft M., Sen S., McNeill V.F., Johnson B.S. and Colton C.K.,
Process Dynamics and Control Experiment Performed Across the Atlantic , Technical Report 27, c4e-Preprint Series, Cambridge, 2004.

[9] Ogata, K., System dynamics , 4th Edition,Prentice Hall Publisher, 2004.

الملخص

في قطاع المياه، يتم تخزين المياه في OHT. يقع هذا حتى الآن من (محطة معالجة المياه) الرغبة في الدفع. هذا أيضا ليس ذلك تسهيلا للمستخدم أن ننظر بعد الخزان، من أجل التحكم في مستوى الماء في الخزان.
والهدف من هذا المشروع هو لإدارة ومراقبة تدفق المياه في المبنى. هذا المبنى يمكن أن يكون مستشفى أو فندق أو بناء طبيعي مع العديد من الطوابق والشقق كتطبيق عملي المساحي.
لبدء إدارة تدفق المياه، وهناك حاجة لفهم النظام بأكمله يتكون من خزانين. أول واحد يتلقى المياه من مضخة تغذية الخزان الثاني صمام جعل الخزانين على حد سواء في التفاعل واسطة.
لتصميم نظام التحكم الذي يتحكم في مستوى في كل من الخزانين، وعلينا أن نبدأ من خلال النمذجة، تحليل نموذجنا ثم التفكير في نوع التحكم لهذا النظام.
أحرز تحليل ونمذجة هذا النظام بمساعدة مطلب والسيميولينك لتحليل مستوى المياه في خزانين، وقد تحقق المواصفات المطلوبة والنتائج هي مناسبة تماما لبدء الجزء التصميم كما اقترح مستقبل الهدف من هذا المشروع هو لإدارة ومراقبة تدفق المياه في المبنى. هذا المبنى يمكن أن يكون مستشفى أو فندق أو بناء طبيعي مع العديد من الطوابق والشقق كتطبيق عملي المساحي ..
لبدء إدارة تدفق المياه، وهناك حاجة لفهم النظام بأكمله يتكون من خزانين، أول واحد يتلقى المياه من مضخة تغذية الخزان الثاني صمام جعل الخزانين على حد سواء في التفاعل واسطة.
لتصميم نظام التحكم الذي يتحكم في مستوى في كل من الخزانين، وعلينا أن نبدأ من خلال النمذجة، تحليل نموذجنا ثم التفكير في نوع التحكم لهذا النظام.

Faculty of Computer & Informatics Engineering

نظام التحكم في المياه داخل المبنى

تم تقديم المشروع الفصلي لكلية هندسة الحاسوب والمعلوماتية لتلبية متطلبات الحصول على إجازة الهندسة في الاتصالات والشبكات والتحكم

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عدنان الكسواني

أديب عربشة

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