

# Multivariable Control System Design for Quadruple Tank Process using Quantitative Feedback Theory (QFT)

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**Abstract**— This paper focus on design of multivariable controller for Quadruple Tank Process, a two input two output system with large plant uncertainty using QFT methodology. In the present work, a new approach using Quantitative Feedback Theory (QFT) is formulated for design of a robust two degree of freedom controller for Quadruple Tank Process. The design is done in frequency domain. This paper presents a design method for a 2 x 2 multiple input multiple output system. The plant uncertainties are transformed into equivalent external disturbance sets, and the design problem becomes one of the external disturbance attenuation. The objective is to find compensator functions which guarantee that the system performance bounds are satisfied over the range of plant uncertainty. The methodology is successfully applied to design a two degree of freedom compensator Quadruple Tank Process.

**Keywords** — Quadruple Tank Process, Robust Control, QFT, MIMO, EDA.

## I. INTRODUCTION

Many practical applications are multi-input multi-output (MIMO) systems. MIMO system is composed of several interacting control loops and numbers of alternative configurations of control loops are very large. Interaction produces several undesirable effects. The design method proposed in this paper consists of design of multivariable controller to have desired response from the plant in the presence of plant uncertainties and external disturbances. The quadruple tank process is a multivariable laboratory process developed by K.H. Johansson[7]. This process consists of four interconnected water tanks and two pumps as shown in figure 1. Here objective to control the level in the lower two tank with two pump.

The Quantitative Feedback Theory (QFT) is a control method in frequency domain which uses the Nichols chart [1]. It is an engineering science devoted to the design problem with quantitative bounds on the plant parameters and quantitative tolerances on the acceptable closed-loop system response. The objective is to find compensator functions which guarantee that the system performance bounds are satisfied over the range of plant uncertainty.

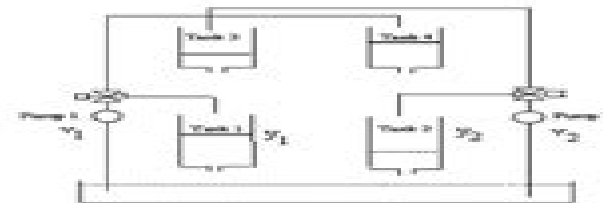


Figure 1: Quadruple tank system.

In this work, we propose a QFT based methodology to design a robust two degree of freedom MIMO compensator for quadruple tank process in the presence of parametric uncertainty. The plant uncertainties are transformed into equivalent external disturbance sets and thus the design problem becomes one of external disturbance attenuation (EDA). The method has been proven rigorous by means of Schauder's fixed point theorem [2]. The design technique is successfully applied to design a two degree of freedom compensator for quadruple tank process.

The present paper is organized as follows: Section II deals with the problem definition for a 2 x 2 MIMO design problem. Basic concepts are discussed in section III. Design equations used in the synthesis of controller for quadruple tank process is given in section IV. Section V deals with the design procedure to design controller and prefilter. In section VI, the methodology is applied to design a compensator for quadruple tank process. Conclusions are drawn in section VII.

## II. A 2X2 MIMO DESIGN PROBLEM

The two degree of freedom controller structure used for the design of two input and two output quadruple tank process is shown in figure 2.

# Multivariable Feedback Control Solution Manual

**Charles G. Schofield**



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non exempt employees it is still important to know if it relates to you as well explain the legal framework and clarify the  
overtime rules let employees know on what day they will receive their salary or wages

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web jun 27 2023 the target employee handbook encompasses various topics including equal employment opportunity  
harassment free workplace diversity and inclusion and safety reporting also addressing policy violations emphasizing  
diversity and inclusion additionally a commitment to creating an inclusive culture are key aspects of the target

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web target location you will be held accountable for understanding and following the code target policies procedures and the  
laws that apply to target when the code is violated if someone violates our policies ignores another team member s  
misconduct or pressures someone to violate our code the impact could damage target s reputation

team members and guests target - Jan 08 2023

web target is committed to continuing to build a diverse workforce that reflects the communities we serve we make data  
driven goals and transparently share progress with our team we set our goals on three year timeframes which provides  
enough time to make meaningful progress as an organization

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web jun 27 2023 the target employee handbook includes policies on equal employment opportunity harassment free

workplace diversity violence free workplace drug free workplace dress code personal and career development pay and benefits employee relations information protection safety and more

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web target employee job duties the job duties of a target employee depend on the department s the employee works in and may include customer service greeting customers helping them ring up or return items and assisting them with locating items light janitorial duties sweeping dusting and vacuuming stocking stocking shelves

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web apr 6 2023 although it varies by store target staff is generally permitted to wear black jeans at work according to the company s employee manual target employees can dress in plain trousers as long as they don t have any patterns or purposeful tears is it permissible for me to wear crocs to target

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web supply chain labor human rights policies human rights are central to how we do business we recognize that we can impact the human rights of our team members guests workers in the supply chain and the people in the communities in which we operate

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web team members are made aware of the code of ethics and reporting channels via new hire and annual ethics training and the employee handbook code of ethics pdf defining ethics at target

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web check out target s employee benefits competitive pay store discount insurance coverage and education assistance are a few of the many perks

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web all target team members are employed at will which means that target can terminate the employment relationship at any time for any reason not prohibited by law team members have the same right therefore except for the policy of at will employment target s policies practices or procedures including this handbook do not

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web oct 18 2022 the employee handbook is an opportunity to welcome new employees provide information about the company and affirm company values in addition to policies and procedures that impact the workplace

target team member handbook airmason blog - Jul 02 2022

web aug 13 2023 the target team member handbook serves as a comprehensive guide to the policies guidelines benefits and resources available to employees it provides essential information for new and existing team members to ensure a safe productive and supportive work environment