

Exhibit 2007

System Dynamics and Control

Eronini Umez-Eronini
Morgan State University



PWS Publishing

An Imprint of Brooks/Cole Publishing Company

ITP An International Thomson Publishing Company

Pacific Grove • Albany • Belmont • Bonn • Boston • Cincinnati • Detroit
Johannesburg • London • Madrid • Melbourne • Mexico City • New York
Paris • Singapore • Tokyo • Toronto • Washington

Sponsoring Editor: *Michael J. Sugarman*
Marketing Team: *Nathan Wilbur, Jean Thompson*
Production: *Clarinda Publication Services*
Cover Design: *Julie Gecha*
Cover Photo: *Corbis*

Photo Research: *Judith Weber*
Typesetting: *The Clarinda Company*
Cover Printing: *Phoenix Color Corporation*
Printing and Binding: *R. R. Donnelley & Sons—Crawfordsville*

COPYRIGHT © 1999 by Brooks/Cole Publishing Company
A Division of International Thomson Publishing Inc.

ITP The ITP logo is a registered trademark used herein under license.

For more information, contact PWS Publishing at Brooks/Cole Publishing Company:

BROOKS/COLE PUBLISHING COMPANY	International Thomson Editors
511 Forest Lodge Road	Seneca 53
Pacific Grove, CA 93950	Col. Polanco
USA	11560 México, D. F., México
International Thomson Publishing Europe	International Thomson Publishing GmbH
Berkshire House 168-173	Königswinterer Strasse 418
High Holborn	53227 Bonn
London WC1V 7AA	Germany
England	International Thomson Publishing Asia
Thomas Nelson Australia	60 Albert Street
102 Dodds Street	#15-01 Albert Complex
South Melbourne, 3205	Singapore 189969
Victoria, Australia	International Thomson Publishing Japan
Nelson Canada	Hirakawacho Kyowa Building, 3F
1120 Birchmount Road	2-2-1 Hirakawacho
Scarborough, Ontario	Chiyoda-ku, Tokyo 102
Canada M1K 5G4	Japan

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transcribed, in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the prior written permission of the publisher, Brooks/Cole Publishing Company, Pacific Grove, California 93950.

Printed in the United States of America.

10 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Umez-Eronini, Eronini,
System dynamics and control / Eronini Umez-Eronini.
p. cm.
Includes index.
ISBN 0-534-94451-5
1. Automatic control. 2. Dynamics—Mathematical models.
3. System analysis. I. Title.
TJ213.U453 1998
629.8—dc21

98-18838
CIP

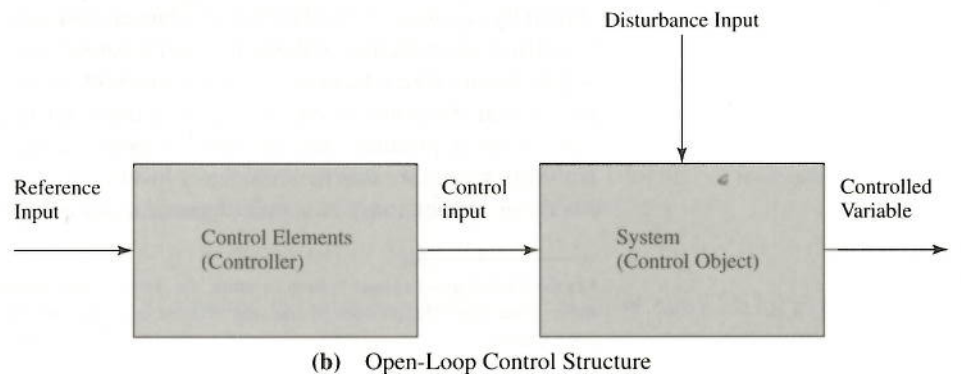
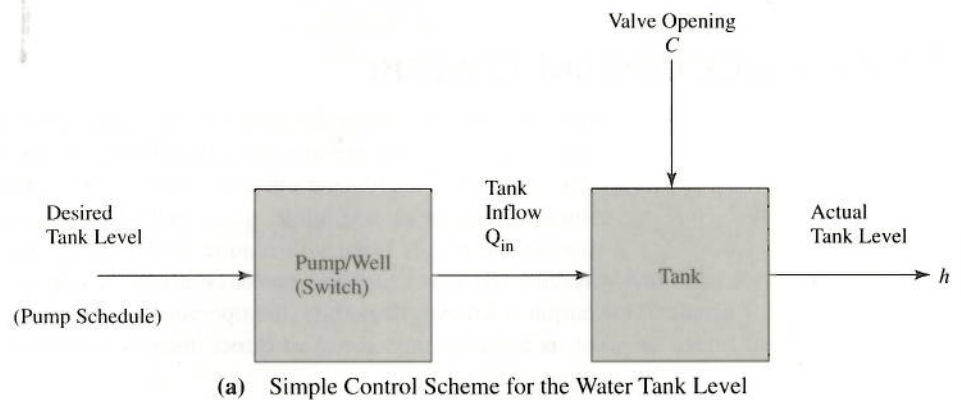


time the aggregate volume of water used at the various sites is fairly uniform and predictable, and that some variation in pressure and therefore performance can be tolerated in the applications, is to operate the pump and fill the tank from the well on some sort of time schedule.

Figure 1.4a shows the way the actual tank water level depends on the scheduled pump operation or the desired tank level. Although the pump operating schedule could have been deduced from, say, statistical analysis of past data on water use on the farm, there is nothing in the control scheme of Fig. 1.4a that prescribes any relationship between one variable of the tank and the other (the variables in this case being Q_{in} and h . The term Q_{out} is related to h through the valve opening parameter C , which is taken here as a perturbation of the system or a disturbance input). Indeed, if at any time the pattern of water use (equivalent valve opening) should deviate significantly from that on which the pump schedule is based, the control system could break down or perform very poorly. This type of control scheme is referred to as *open-loop control*.

The structure of an open-loop control system is shown in Fig. 1.4b. The specific characteristic or variable of the system, the output, that we wish to control is referred to as the *controlled variable*, whereas the characteristic or variable that is determined by the control action is called the *control input*. The control elements can collectively be called the *controller*, although, as we shall see later, the control elements can be contained in other subgroups. The *reference input* generally implies the desired value of the controlled variable. In Fig. 1.4b the loop is open in the sense that there is no path through which the control input can be determined in terms of the controlled variable, that is, the controller does not prescribe a relationship between the control input and the controlled variable.

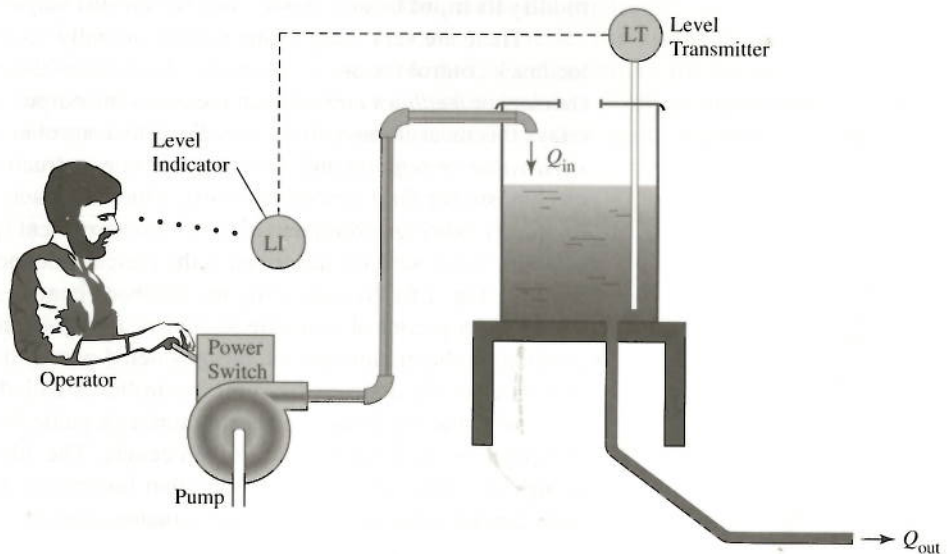
Figure 1.4
Open-loop Control of Water Supply System



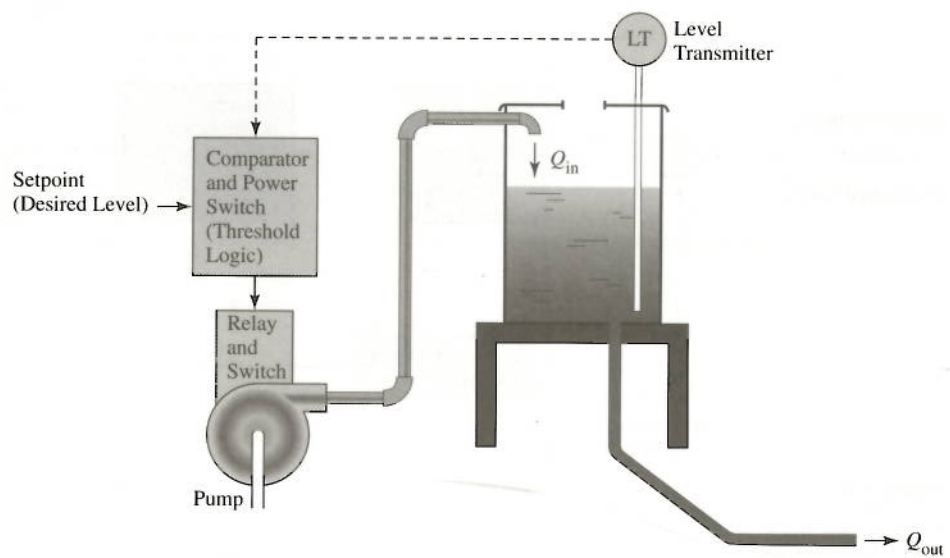
Feedback Control Structure

Another approach to the control of the water tank level is to have the pump operator turn the pump on whenever the tank water level drops below the reference value and to turn it off again when the tank fills beyond the reference level. To facilitate the work of the operator, a level measuring/transmitting and indicating system (LT and LI) can be connected to the tank and used to display the tank level at a location where it can conveniently be observed (see Fig. 1.5a). The result is a *closed-loop control system*, since there is a prescribed (albeit switching) relationship between the tank level and input flow. The operator observing the tank level provides the path that closes the loop. However, a control system with a human operator as an element of the controller is *manual*, that is, not automatic. On a busy farm or where it is not feasible to dedicate an employee to operation of the pump only, such manual control would clearly be in-

Figure 1.5
Manual and Automatic Control of Water Tank Level



(a) Manual Closed-Loop Control of Tank Level



(b) Automatic Closed-Loop Control of Tank Level

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.