Teoria de control ogata

1. Modern Management Engineering 5th Edition of Katsuhiko Ogata 2. Modern Engineering Control Technique 3. 4. Modern Engineering Management Fifth Edition Katsuhiko Ogata Translation by Sebastian Dormido Kanto Professor of Systems Engineering and Automatic, UNED Raquel Dormido Canto Professor of Systems Engineering and Automatic, UNED Technical Review Sebastian Dormido Bencomo Professor of Systems Engineering and Automatic, UnED Technical Review for Latin America Amadeo Mariani Professor of Advanced Systems Management UTN Regional Buenos Aires Regional / HAEDO Juan Eduardo Picco Professor of Electronic Engineering Regional University of Technology Cordoba, Province of Cordoba, Argentine Republic Professor of Theory of Management, University of Province of Cordoba, Argentine Republic Ricardo Julian Manz Professor, Faculty of Engineering of La Plata, Buenos Aires Province, Argentina Jorge Raul Rossello Professor of Systems Management Department 1 Faculty of Engineering, National University of San Justosto Matanza, Buenos Aires Province, Argentina 5. 78-84-84-8322-660-5 Material: Automatic Management Engineering, 681.5 Format: 195-250 mm. Pages: 904 5 PEARSON EDUKASION, S.A., 2010 Ribera del Loire, 28 28042 Madrid (Spain) www.pearsoneducacion.com ISBN: 978-84-8322-660-5 Legal Deposit: M Authorized Translation from English Edition, Entitles TO MATERIALS SCIENCE FOR ENGINEERING, 7th edition of JAMES SHACKELFORD, published by Pearson Education, Inc., Publishing as Prentice Hall, Copyright 5 2009. SPANISH language publication published by PEARSON EDUCATION S.A., Copyright 5 2010. Editorial: Miguel Martin-Romo Editorial Technician: Esther Martin Production Group: Director: Jose Antonio Clares Technician: Isabel Munoz Cover Design: Pearson Design Team S.A. Composition: Copibook Print: PRINTED IN SPAIN - PRINTED IN SPAIN This book was printed with paper and eco-friendly ink Prolog Content

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viii Content 10. Prologue This book introduces important concepts in the analysis and design of control systems. Readers will find a clear and understandable textbook for a university course on management systems. It is written for students of mechanical, electrical, aero-pachial or chemical engineering. It is assumed that the reader has fulfilled the following prerequisites: introductory courses on differential equations, laplace transformation, analysis of vectault-rial-matrix, system analysis, mechanical and thermodynamics. The main changes made in this edition are: the use of MATLAB has been expanded to Management systems respond to different inputs. Demonstrated the usefulness of the approach to computational optimization with MATLAB. New problems were added throughout the book as examples. In order to provide space for more important topics, some mat-rial from previous editions that are of secondary importance have been removed. Signals flow graphs have been removed from the work book. A chapter on Laplace's transformation was also removed. Instead, Laplace turn tables and development into simple factions with MATLAB presented in applications A and B respectively. A brief summary of vector-matrix analysis is given in Annex C. This edition of Modern Management Engineering is organized in ten chapters. The Conteni-up book is this: Chapter 1 presents an introduction to the management system. Chapter 2 is devoted to mathematical modeling of control systems. This chapter also presents the methodology of a linear nonlineary mathematical model. Chapter 3 discusses mathematical modeling of mechanical and electrical systems. Chapter 4 focuses on the simulation of liquid systems (such as liquid-level systems, pneumatic and hydraulic systems) and thermal systems. Chapter 5 examines the analysis of the temporary response and the stationary state of the control system. MATLAB is widely used to analyze transitional responses. The chapter presents the criterion of Ruth's stability for the analysis of the stability of management systems. The Hurwitz stability criterion is also being studied. Chapter 6 examines the analysis and design of management systems by locating rules, including positively improved systems and conventionally esta-ble systems. The view of the root site is studied in detail with the help of MATLAB. The root site method for developing compensators in advance, delays and delays is being studied. Chapter 7 provides analysis and design of control systems using frequency response. Nyquist's stability criterion is seen in an easily understandable way. The Bode diagram method for forward design, delay and pre-compensators is analyzed. Chapter 8 explores basic and modified PID controllers. Computing methods (in MATLAB) are presented in some detail to get the best parameters of controllers that meet certain step response requirements. Chapter 9 provides a basic analysis of governance systems in the state space. Concepts of controllability and observability are introduced. Chapter 10 discusses the design of management systems in the state space. Study includes appointment of poles, government observers optimal square control. At the end of the chapter is an introductory analysis of reliable management systems. The book was structured in order to facilitate a gradual understanding of the theory of control for the student. He was carefully seeking to avoid reasoning with a strong mathematical conte-nest in the presentation of the material. Mathematical demonstrations are provided when they contribute to the understanding of the themes presented. Special efforts have been made to provide examples in strategic locations so that the reader has a better understanding of the topic being analysed. In addition, at the end of each chapter, with the exception of Chapter 1, a number of problems (type A) are addressed. The reader is encouraged to look closely at all these issues in order to gain a better understanding of the topics under discussion. In addition, many problems (without a solution) are offered at the end of each chapter, with the exception of Chapter 1. Unsolved problems (type B issues) can be used for the student to resolve at home or within the exam. If this book is used as a text for a six-month course (56 hours class), most of the material can be covered by lowering certain parts. Because of the abundance of problems and problems solved (problems A) that can respond to many of the possible pre-guntas that the reader may represent, this book can also serve as a self-learning text for those engineers who are already working and who want to study the basic theory of control. I would like to thank the following reviewers for this edition of the book: Mark Campbell, Cornell University; Henry Sodano, Arizona State University; and Atul G. Kelkar, Iowa State University. Finally, I would like to express my sincere gratitude to Ms. Alice Dvor-kin, Assistant Editor, Mr. Scout Disanno, Mr. Managing Editor, and to all the people who participated in this project, for the speed and excellent production of this book. Katsuhiko Ogata x Prologue 12. Introduction to Control Systems 1-1 Introduction Control Theory is commonly used by classical management theory (also called conventional management theory), modern management theory, and reliable management theory. This book presents the processing of analysis and design of management systems based on classical management theory and modern management theory. Chapter 10 includes a brief introduction to a robust theory of control. Automatic management has played a vital role in promoting engineering and the 100th. Automatic control has become an important and integral part of spacecraft systems, robotic systems, modern manufacturing processes and any industrial operation requiring temperature, pressure, humidity, flow management, etc. that most engineers and scientists are familiar with the theory and practice of automatic control. This book is designed for text in control systems for advanced level in bachille-rato or university. All the necessary materials are included in the book. Mathematics related to Laplace and vector transformations and matrix analysis are presented in individual applications. A brief overview of the historical events of the theory and practice of the con-troll. The first important work in the field of automatic control was the centrifugal fugue of the speed controller James Watt to control the speed of the steam engine, in the nineteenth century Cho. Minorsky, Hazen and Nyquist, among many others, contributed important work in 13. 2 Modern engineering management management initial stages of the development of management theory. In 1922, Small worked on automatic controllers to guide the boat, and showed that stability can be defined from the differential equations that describe the system. In 1932, Nyquist developed a relatively simple pro-cudin to determine the stability of closed cycle systems, based on the open cycle response to the stationary sinus inputs. In 1934, Hazen, who coined the term seromecanisms for position management systems, analyzed the design of relay seromecanisms capable of accurately following the changing input. In the 1940s, frequency response techniques (especially Bode diagrams) enabled engineers to develop closed-loop linear control systems that met behavioral requirements. In the 1940s and cin-count, many industrial control systems used PID controllers for pressure, temperature control, etc. In the late 1940s and early 1950s, Evans's root seating method was developed by com-pleto. The root site and frequency reaction techniques that make up the core of classical management theory lead to stable systems that meet a more or less arbitrary set of behavioral requirements. In general, these systems are acceptable, but not optimal from any point of view. Since the late 1950s, the focus on management design has shifted from designing one of the possible systems that works well to developing the optimal system compared to some criteria. As modern factories with more entrances and exits become more and more complete, the description of the modern management system requires many equations. Control theory which deals with input and output systems, loses its potential when dealing with systems with multiple inputs and outputs. By 1960, debi-do to the availability of digital computers, time analysis of complex systems was possible. Modern management theory, based on the analysis and synthesis of time from government variables, has been designed to handle the growing complexity of modern factories and the increasingly demanding requirements for accuracy, weight and cost in military, space and industrial applications. Between 1960 and 1980, the optimal management of both deterministic and stochastic systems, as well as adaptive and adaptive-disage management of complex systems, was thoroughly researched. From the 1980s to the 1990s, advances in modern control theory focused on robust control and related topics. Modern management theory is based on analysis in the temporal area of differential systems of equations. Modern management theory has simplified the design of control systems because it is based on a real system model that you want to control. However, the stability of the system depends on the error between the actual system and its model. This means that when you apply a model-based driver to a real system, it may not be stable. To avoid this situation, the control system is designed by first identifying a range of possible errors and then designing the controller so that if a system error is in that range, the developed control system remains stable. The design method based on this principle is called a reliable management theory. This theory includes both the approximation of the frequency reaction and the approach of the temporary domain. This theory is very complex. Chapter 1. Chapter 1. Introduction to Control Systems 3 Because this theory requires a mathematical basis at the graduate level, the inclusion of a reliable management theory in this book is limited only to introductory aspects. Lec-tor are interested in the details on a reliable management theory should previously take a bachelor's degree course at the university. Definition. Some basic terms need to be defined before you analyze the controls. Controlled variable and control signal or manipulated variable. A controlled variable is a quantity or condition that is measured and controlled. A manipulated control signal or variable is the number or condition that the controller changes to affect the value of the controlled variable. Typically, a controlled variable is the output of the system. Control means measuring the value of a system-controlled variable and applying a manipulated variable to a system to correct or limit the deviation of the measured value from the value When studying engineering management, you need to identify additional terms needed to describe the management systems. Plants. The plant may be part of a team, perhaps a set of machine elements that work together and whose goal is to perform a specific operation. In this book, any physical object that will be controlled (e.g. a mechanical device, a heating furnace, a chemical reactor or a spaceship) will be called a factory. Processes. The Merriam-Webster dictionary defines the process as a gradual continuous natural operation or development marked by a series of gradual changes that occur with each other in a relatively fixed manner and lead to a certain result or goal; or an artificial or voluntary operation that is carried out gradually and consists of a series of controlled actions or movements systematically directed at the result or purpose. In this book, any operation that will be monitored will be called processing. Examples include chemical, economic and bioliga-cos-processes. System. The system is a combination of components that work together and fulfill a certain purpose. The system is not necessarily limited to physical systems. The con-brush system can be applied to abstract and dynamic phenomena, such as those in the economy. Therefore, the word system should be interpreted in a broad sense, including physical, biological, economic and similar systems. Violations. A violation is a signal that tends to have a negative impact on the output value of the system. If a violation is generated inside the system, it is called internal, while the external violation is generated outside the system and is input. Real control. Real control refers to an operation that, if there is a breach, tends to reduce the difference between the output of the system and some reference input, and does so in view of this difference. Only unpredictable violations are specified here, as predictable or known siem-pre violations can be compensated in the system. 15. 1-2 Examples of Management Systems This section will present several examples of management systems. Speed control system. The basic principle of the watt speed regulator for the machine is illustrated on the schematic chart in figure 1-1. The amount of fuel that is supported in the car is adjusted depending on the difference between the speed of the alleged machine and the actual speed. The sequence of actions can be described as follows: the speed controller is regulated so that at the right speed no oil pressure flows anywhere on the power cylinder. If the actual rate falls below the desired value due to a violation, Reducing the centrifugal force of the speed control forces causes the control valve to move downwards, providing more fuel, and the engine speed increases to the desired value. On the other hand, if the engine speed increases above the seed value, the increase in the centrifugal force of the regulator causes the control valve to move upwards. This reduces the fuel supply and reduces the engine speed to the desired value. In this speed control system, the plant (control system) is a machine and the controlled variable is the speed machine. The difference between the desired speed and the actual speed is the error signal. The control signal (the amount of fuel) that will be applied to the plant (machine) is an action signal. The external input that is used to change the controlled variable is a violation. An unexpected change in load is pertur-bation. Temperature control system. Figure 1-2 shows a schematic scheme to control the temperature of the electric furnace. The temperature of the electric furnace is measured by a thermometer, which is an analog device. Analog temperature is converted to digital temperature using the A/D converter. This digital temperature is compared to the pre-programmed input temperature, and if there is a mismatch (error), the controller sends a signal to figure 1-1. Speed control system. 4 Modern Management Engineering 16. Chapter 1. Introduction to Control Systems 5 Figure 1-2. Temperature control system. Heater, through interface, amplifier and relay to allow the oven temperature to acquire the desired value. Business systems. The business system is made up of many groups. The Ca-da task assigned to the group will be a dynamic element of the system. In order for the system to function properly, feedback methods must be established to report on the achievements of each group. Cross-connection between functional groups should be minimized to avoid time delays that are not desirable in the system. The smaller the connection, the more regular the flow of signals and working materials. A business system is a closed system. Its good design will reduce the necessary administrative control. Please note that the irregularities in this system are staff shortages or materials, interruptions, huma-nos errors, etc. Note that it is well known that the behavior of such a system can improve with the time of forecasting or waiting. In order to apply to improve the behavior of this system-ma, the dynamic characteristic of the components of the me-diante system should be represented by a set of relatively simple equations. While getting mathematical representations of gru-pos components is certainly a challenge, applying optimization techniques to enterprise systems significantly improves the behavior of such systems. Consider, for example, an organizational structure in the field of design, which consists of a number of groups such as management, research and development, preliminary design, experimentation, product design and demarcation, production and assembly and verification. These groups are interconnected and make up the whole system. Such a system can be analyzed by reducing it to the most basic set of necessary components, which provides the necessary analytical details and presents the dynamic characteristics of each component using a set of simple equations. (Dynamic behavior of this system can be determined on the basis of the relationship between progressive results and time.) You can draw a functional diagram of the block using blocks to represent functional actions and connection signal lines to represent information output 17. Figure 1-3. Block diagram of the engineering organization system. or the product of the system. Figure 1-3 shows a possible block pattern. A reliable control system. The first step in designing a control system is to get a mathematical model of a plant or control facility. In fact, any mo-delo from the plant you want to control will involve an error due to the modeling process. That is, the actual plant is different from the model that will be used in the design of the control system. A reasonable approach to ensuring that a model-based controller works properly when used with an actual plant is to assume from the outset that there is uncertainty or error between the actual plant and its mathematical model, and to incorporate such uncertainty or error into the management system design process. The control system developed from this approach is called a reliable control system. If the actual plant to be controlled, should be G3 (s) and that the mathematical model of the actual plant G (s), it is the G3 (s)%actual model of the plant, which has uncertainty B (s) G (s)% nominal model of the plant to be used in the design of G3 (s) and G (s) control system can be associated with a multiplier factor type G3(s) B(s) or addive factor G3 (s)s) B (s) or other ways. Since the exact description of uncertainty or error B (s) is not known, a B (s) score is used and this estimate, W (s), is used in the design of the controller. W (s) is The Scalar Type B (s)-aW(s)-%max 0mum-W(ju) function, where W (s) is the maximum value of W/ju) for 0mum-y, called W (s) infinite standard H. If you use a small win's theorem, the design process involves identifying the K/s controller, which satisfies inequality, GG W (s) 1! K(s)G (s) GG-a1 6 Modern Engineering Control Technology 18. Chapter 1. Introduction to Control System 7, where G (s) is a model transfer function used in the design process, K (s) is a function of the transmission controller and W (s) is selected as a transmission function that approaches B (s). In most case studies, more than one inequality depends on G (s), K (s), and W (s) to be satisfied. For example, providing reliable stability and reliable com-porting requires that the following two GGWm (s)G (s)G inequalities be satisfied! K(s)G (s) GG-a1 for reliable stability GG Ws (s) 1! K(s)G (s) GG-a1 for reliable behavior (section 10-9 subtract these inequalities). There are many inequalities of this kind that need to be addressed in many different systems of reliable control. (Ro-busta stability means that the K controller (s) provides internal stability to all systems belonging to the group of systems representing the actual system of the plant. This book suggests that all plants in the presented control systems are well known, except for the plants discussed in section 10-9, which presents the introductory aspects of a robust control theory. 1-3 Closed cycle management compared to open re-maintained cycle management systems. A system that connects output and reference input by comparing them and using the difference as a control is called a rebuilt control system. An example would be the temperature control system in the room. By measuring the actual temperature and comparing it with the reference temperature (desirable temperature), the thermostat activates or deactivates heating or cooling equipment to ensure a comfortable room temperature state regardless of external conditions. Reconstructed control systems are not limited to engineering, but are also located in various areas beyond. For example, the human body is a very advanced real control system. Body temperature and blood pressure are in a constant state through physiological feedback. In fact, feedback enhances a vital function: it makes the human body relatively insensitive to external disorders, allowing it to function properly in the environment Closed cycle control systems. Supported control systems are also identified in closed loop management systems. In practice, reali-lied control and closed cycle control are used interchangeably. In a closed loop management system, the controller is fed an active error signal, which is the difference between the input signal and the feedback signal (which may be the output signal itself or the output signal function and its derivatives and/or integrals) in order to reduce the error and bring the system's output to the desired value. The term closed control loop always includes the use of re-run management actions to reduce system errors. 19. 8 Modern engineering management systems for the Open Management Cycle. Systems where output does not affect management are called open cycle management systems. In other words, the open loop management system does not measure output or stand out to compare it to the input. A practical example is a washing machine. Soaking, washing and leaking centrifies in the washing machine work on a time-based basis. The machine does not measure the output signal, which is cleaning clothes. In any open cycle management system, the output is not compared to the reference entry. Thus, each reference record has a fixed state of operation; as a result, the accuracy of the system depends on the calibration. If there is interference, an open cycle control system does not perform the desired task. In practice, open cycle management is only used if there is a known relationship between entry and output and if there are no internal or external violations. It is clear that these systems are not real-lies control. Please note that any time-based control system is in an open loop. For example, time-based motion management is another example of open cycle management. Closed loop management systems compared to open loop systems. One of the advantages of a closed loop management system is that the use of feedback makes the system's response relatively insensitive to external interference and internal addresses in the system settings. Thus, relatively inexpensive and inexpensive components can be used to gain proper control over the plant, when this is not possible in the case of an open cycle system. In terms of stability, the open cycle management system is easier to develop because the stability of the system is not a serious problem. On the other hand, stability is a big problem in the closed loop management system, which can lead to excessive correction of errors that produce constant or changing amplitude fluctuations. It should be noted that in order to systems in which inputs are known in advance and where there are no violations, it is advisable to use open cycle control. Closed loop management systems have advantages only if there are unpredictable violations and/or changes in the components of the system. Note that the nominal power of sali-da partially determines the cost, weight and size of the control system. The number of components used in the closed loop management system is greater than for an equivalent open loop management system. Thus, a closed loop management system often has high costs and powers. To reduce the required power of the system, it uses an open control cycle. Typically, an adequate combination of open loop and closed cycle controls is less costly and will ensure satisfactory global behaviour. Most of the systems of analysis and design of control systems presented in this book are closed loop control systems. In certain circumstances (e.g. if there are no violations or the conclusion is difficult to measure) open to the cycle management systems may be desirable. Therefore, it is advisable to summarize the pros and cons of using open cycle management systems. The main advantages of open cycle management systems are: 1. Simple design and ease of service. 2. Cheaper than the appropriate closed-loop system. 3. There are no problems with stability. Chapter 1. Introduction to Control Systems 9 4. Conveniently, when the output is difficult to measure or when accurately measured, the output is not economically feasible. (For example, in the case of a washing machine, it would be expensive to provide a device to measure the quality of the washing socket, i.e. cleaning the washing clothes.) The main drawbacks of open cycle management systems are: 1. Violations and calibration changes cause errors, and the output may be different from what you want. 2. Recalibration is required from time to time to maintain the necessary quality on the way out. 1-4 Design and Compensation Management Systems This book presents the main aspects of design and compensation management systems. Compensation is to change the dynamics of the system so that some specifications are satisfied. The approaches to the design of management and compensation systems, presented in this book, are an approximation to the root site, frequency reaction and approximation in the state space. The design of the control systems used by these methods is presented in chapters 6, 7, 9 and 10. The design of PID compensator control systems is presented in Chapter 8. In actual design the control system, whether electronic, pneumatic or hydraulic compensator is used, should be decided in part in accordance with the nature of the controlled plant. For example, if a controlled plant contains flammable liquids, pneumatic components (both compensator and drive) should be used to eliminate the possibility of sparks jumping. However, if there is no fire risk, electronic compensation is most commonly used. (In fact, it is common to convert non-electric signals into electrical signals, due to ease of transmission, greater accuracy, greater reliability, greater ease of compensation, etc.) Behavioral characteristics. Control systems are designed to perform specific tasks. The requirements for the management system are given as behavioral specifications. Specifications can be given as requirements for transient overwork (e.g., the maximum time to overlong and calculate in response to a step) and requirements in a stationary state (such as a stationary error compared to the entrance to the ramp). The control system specifications must be given before the design process begins. For conventional design problems, behavioral specifications (which are diet accuracy, relative stability, and response rate) are provided in terms of exact numerical values. In other cases, one or another part is proposed in terms of exact numerical values, and the other part in terms of qualitative approaches. In the latter case, it may be necessary to change the specifications during the design process, as it is possible that these specifications will never be met (because the requirements produce con-files) or lead to a very expensive system. Typically, behavior specifications should not be more restrictive than necessary for a particular task. If the accuracy of stable performance is vital to the management system, no more restrictive compor-tamiento specifications should be requested than is necessary for a transitional response, since such requirements are 21. 10 Modern management engineering will require expensive components. Keep in mind that the most important part of the management system design is accuracy in approaching behavioral specifications to get the best management system for the desired purpose. Systemic compensation. Installing amplification is the first step in bringing the sis-theme to satisfactory behavior. However, in many case studies, a subtle benefit adjustment may not provide sufficient changes in the system's behaviour to meet these specifications. As is often the case, Gain va-lor improves the sustainable behavior of the state, but produces poor stability or even instability. In this case, you need to restructure the system (change the structure or include additional devices or components) to change the overall com-porting, so that the system behaves at will. This new design or addition of the device is called compensation. The item inserted into the system to meet the specifications is called a compensator. The compensator changes the bad behavior of the original system. Design procedures. In the aproximation of the test and the error for the design of the system it is based on the mathematical model of the control system and the parameters of the compensator are adjusted. Part of this process that takes the most time is to test the com-porting system through analysis after each adjustment of the parameters. The system should use a computer program such as MATLAB to avoid most of the numerical calculation required for this check. After obtaining a satisfactory mathematical model, the designer must build a prototi-po and test the system in an open loop. If the open loop is absolutely stable, the designer closes the loop and checks the behavior of the closed loop system. Because of the load effect not taken into account between components, lack of linearity, distributed parameters, etc., which were not included in the original design, it is likely that the actual com-porting of the system prototype differs from theoretical projections. Thus, the first design may not meet all behavioral requirements. Using a testing method and an error method, the designer must change the prototype until the system meets the specifications. You should analyze each test and include the results of this test in the si-guide test. The designer needs to make sure that the final system meets compression specifications, being reliable and economical. 1-5 Book Content Book is organized in 10 chapters. The contents of each chapter are summarized below. Chapter 1 presents an introduction to the book. Chapter 2 examines the mathematical modeling of control systems described by linear differential equations. In particular, transmission functions and differential equations are presented when describing systems. Equations in the state space are also analyzed. MATLAB is used to transform mathematical models described by different functions of state space transmission and vice versa. This book covers linear systems in detail. If the mathematical model of any system is non-linear, it must be sloping before it can apply the theories presented in this book. This chapter linear non-linear mathematical model. Chapter 1. Introduction to Control Systems 11 Chapter 3 focuses on mathematical modeling of mechanical systems and electrical systems that often appear in control systems. Chapter 4 focuses on the mathematical modeling of liquid systems and thermal systems that are common in control systems. Fluid systems include liquid-level systems, pneumatic systems and hydraulic systems. In addition, this chapter presents thermal systems such as temperature control systems. Chapter 5 provides an analysis of the temporary response response to the staff of control systems determined by transmission functions. In addition, detailed information about transitional responses and outdated response analyses is provided through MATLAB. It also introduces how to get 3D charts with MATLAB. This chapter also presents an analysis of stability based on Ruth's stability criteria and summarizes the Hurwitz stability criterion. Chapter 6 outlines an analysis of the root section of control systems. This is a graphic method for determining the location of all closed loop poles based on knowledge of open loop pole positions and a closed zero cycle system, when the setting (usually obtained) varies from zero to infinity. This method was developed by W.R. Evans in 1950. Currently, MATLAB allows you to get a root site schedule easily and quickly. This chapter presents both a guide getting root space and generating a place using MATLAB. This chapter also explores the development of management systems using forward, overdue and backward compensation. Chapter 7 provides a method for analyzing the frequency response of control systems. It is the oldest method of analysis and design of control systems, developed in 1940-1950 by Nyquist, Bode, Nichols and Hazen among others. In this chapter, before the proposals are made, the frequency of management systems is detailed using the upfront compensation method, the method of debt compensation and the method of compensation for delays. The method of frequency response was a method of analysis and widely used has-that design that the method in the state space has become the most popular. However, since H's endless reliable design management method has gained popularity, the fre-cuencia response is back in vogue. Chapter 8 covers basic and modified PID controls, such as PID controllers with varying degrees of freedom. The PID controller has three parameters: proportional gain, integrated ga-nansia and profit In industrial control systems, more than half of the controllers used are PID controllers. The behavior of the DE-penDE PID controllers relative to the value of these three parameters. Determining the relative values of these three parameters is called setting up the PID controller. Siegler and Nichols proposed the so-called Siegler-Nichols Settings Rules to the co-chairs of 1942. Since then, numerous customization rules have been proposed. Today, the production of PID controllers has its own customization rules. This chapter introduces a computer optimization procedure using MATLAB to determine three parameters so that the characteristics of this transitional response are met. This procedure can be expanded to define three parameters, so that any characteristic is satisfied. Chapter 9 presents the basic material for analyzing state equations. The concepts of controllability and observability, the most important concepts of modern management theory, thanks to Kalman, are completely analyzed. This chapter stems from the solution of state equations. 23. Chapter 10 Modern Engineering Management considers the design of management systems in public space. This chapter begins with problems with the appointment of poles and state observers. When designing a management, it is often advisable to set a behavior index and try to minimize it (or maximize it if applicable). If the behavior index you choose has a clear physical value, this method is useful enough to determine the optimal variable control. This chapter presents the problem of optimal square control, which uses a behavior index that is an integral part of the square function of state variables and variable controls. Integral is rated from t%0 Up to t%. This chapter ends with a brief discussion of sound management systems. 24. Mathematical Simulation of Control Systems 2-1 Introduction When studying control systems, the reader should be able to model dynamic systems and analyze dynamic characteristics. The mathematical model of a dynamic system is defined as a set of equations that accurately reflect the dynamics of the system, or at least quite well. Keep in mind that the mathematical model is not unique to this system. The system can be presented in different ways, so it can te-ner many mathematical models, depending on each point of view. The dynamics of many systems, whether mechanical, electric, thermal, economical, biological, etc., are described in terms of differential equations. These different equations are derived from the physical laws governing a particular system, such as Newton's laws for Kirchhoff's mechanics and laws for electrical systems. Keep in mind that getting a reasonable mathematical model is the most important part of the whole analysis. Throughout this book, it is assumed that the principle of causality applies to the systems that are being considered. This means that the current output of the system (exit in t%0) depends on the traversed inputs (entrances to ta0), but does not depend on future inputs (inputs for tb0). Mathematical models. Mathematical models can take different forms of dis-inks. Depending on the specific system and specific circumstances, the mathematical model may be more convenient than others. For example, with optimal control issues, it is advantageous to use representations in the state space. Instead, to analyze the 25th. 14 Modern engineering management transitional response or frequency response of linear systems with invariant input and output over time, visualization function transmission may be more convenient than any other. After receiving the mathematical model of the system, various analytical resources are used, as well as computers to study it and synthe-sallo.

Simplicity versus accuracy. When you get a mathematical model, you need to find a trade-off between the simplicity of the mathematical model and the accuracy of the analysis results. With a fairly simplified mathematical model, you often have to ignore certain physical properties inherent in the system. Specifically, if you're going to get a mathematical mode-lo linear concentrated parameters (i.e. one that uses differential equations), it's always necessary to ignore certain non-linear and distributed two parameters that may be present in a dynamic system. If the impact of these neglected properties on the reaction is small, there will be good agreement between the results of the mathematical model analysis and the results of an experimental study of the physical system. In general, when solving a new problem, it is advisable to first develop a simplified model to get a review of the solution. A more complete mathematical model with more detailed information is then developed and used. It should be known that a linear concentrated parameter model, which can be valid when operating at low frequency frequencies, may not be valid at high enough frequencies, as the ness of distributed parameters can be an important factor in the dynamic behavior of the system. For example, the mass of a spring can be ignored in low-frequency operations, but it becomes an important feature of the system at high frequencies. (In the event that the mathematical model takes into account the considerations of error, the theory of management can be applied The theory of reliable management is presented in Chapter 10) Linear Systems. The system is called linear if the principle of superposition is applied. This principle states that the response from the simultaneous application of two different input functions is the sum of two separate responses. Thus, for a linear system, the response to multiple inputs is calculated by processing one record at a time and summarating the results. This principle allows us to develop complex solutions for linear diph-Renzial equations from simple solutions. If the cause and effect are proportional in the experimental study of the dynamic system, which means that the overlapping principle is applied, the system is considered linear. Linear systems invariant and variants over time. The differential equation is linear if its ratios are permanent or only an independent variable functions. Dynamic systems formed by the components of linear concentrated parameters are eventually described by linear differential invariant equations over time - constant coefficients. Such systems are eventually called invariant linear systems (or linear constant coefficients). Systems represented by differential equations, the coefficients of which are functions of time, are called linear time-variant systems. An example of a control system option over time is a spacecraft control system. (The mass of the spacecraft changes due to fuel consumption.) Chapter 2. Chapter 2. Mathematical Simulation of Control Systems 15 Chapter Content. Introduction to the mathematical model of dynamic systems is presented in section 2-1. Section 2-2 presents the transmission function and the impulse reaction. Section 2-3 introduces automatic control systems, and section 2-4 discusses the concepts of state space modeling. Section 2-5 is a dam in a dynamic system of public space. Section 2-6 focuses on the transformation of mathematical models with MATLAB. Finally, section 2-7 discusses the linearization of non-linear mathematicians. 2-2 Transmission and Response Impulse Function In Management Theory, transmission functions are often used to characterize input output ratios of components or systems that are described as invariant linear differential equations over time. You will start by defining the transmission-cia function to continue calculating the function of transferring the system of differential equations. The pulse response function is discussed below. Transmission function. The transmission function of the system described by the linear and ivariant differential equation over time is defined as the ratio between the Laplace conversion (response function) and Laplace's conversion input (arousal function) provided that all initial conditions are zero. Consider the linear and variant system at the time described by the following differential equation: a0 (n.1) (n) y!a1y!' a.1 y5!an and %b0 (m) x! (m.1) b1x !! bm.1x5!bmx (nnm), where y is the output of the system and x is input. The function of transferring this system is to convert Laplace output and convert Laplace input when all initial conditions are zero, o Transfer function%G (s)% (exit) (entry) Initial Gcondes zero % Y (s) X (s) % b0sm!b1sm.1!' 1!bm.1s!bm a0sn!a1sn.1! You can imagine the dynamics of the system using algebraic equations in s. If the highest power s in the signer of the transmission function is n, the system is called nth order system. Comments on the transfer function. The application of the transmission function concept is limited to systems described by linear differential equations that are never-before-come over time; however, the approach to transmission function is widely used in the analysis and design of such systems. Here are some important comments related to the transmission feature: (Please note that the list mentions systems described by the linear and eternal differential equation.) 27. 1. The system transfer function is a mathematical model because it is an operational method of expressing a differential equation that links the output variable to the input variable. 2. Transfer function is a function of the system, regardless of the magnesium-there and the nature of the input or arousal function. The transmission function includes the units needed to communicate the input-to-exit ratio; however, it did not provide information on the physical structure of the system. (The transmission functions of many physically different systems can be identical.) 4. If the system transfer function is known, output or respues-ta is studied for various forms of input, with the intention of understanding the nature of the sis-theme. 5. If the transmission function of the system is unknown, it can be installed by an empirical tool by entering known inputs and studying the output of the system. Once the transmission function is installed, it provides a full description of the system's dynamic characteristics as a contrast to its physical description. Integral roll. For a linear and timeless system, the G transmission function (s) is G (s)% Y (s) X (s) where X (s) is Laplace conversion and Y (s) is a Laplace conversion exit, and all the initial conditions involved are supposed to be zero. From this it turns out that the output Y (s) is written as a product G (s) and X (s), or Y(s)%G (s)X (s) (s) (s) Please note that multiplying in a complex domain is equivalent to a time rolled (see annex A), so that the reverse conversion of the Laplace equation (2-1) is received by the next bundle integral: y/t)%It 0 x(q)g (t.q) dq %It 0 g(q)x (t.q) dq where and g(t) and x/t) 0 for ta0. Pulse-response. Consider exiting (response) systems to enter a momentum unit when the initial conditions are zero. As laplace is the function of the unit impulse function, the implementation of the Y System Exit Laplace (s)%G (s) (2-2) is 16 Modern Control Engineering 28. Chapter 2. Mathematical Simulation of Control Systems 17 Reverse Transformation of output obtained by Equation (2-2) provides a reaction-pulse system. The reverse conversion of Laplace G (s), or .1'G (s)'g (t) is called impulse reaction. This g(t) response is also called system weighing function. Thus, g(t) impulse reaction is the reaction of the linear system to the input of the pulse unit when the initial conditions are zero. Laplace's conversion of this feature provides a transmission function. Thus, the transmission function and re-pulse of the linear and ivarian system over time contain the same information about the dynamics of the system. Thus, you can get complete information about the dynamic characteristics of the system if the system is triggered by impulse input and the reaction is measured. (In practice, impulse input with a very short duration compared to significant constants of systemic time is considered a boost.) 2-3 Automatic Control Systems Control System can have multiple components. A view called a block diagram is usually used to display the functions of each component in management engineering. This section first explains what a blo-ques chart is. Here are the introductory aspects of automatic control systems, including various controls. The method of obtaining flea charts of physical systems is then exposed, and finally methods for simplifying such diagrams are analyzed. Blocks diagrams. The system block diagram is a graphic representation of the functions performed by each component and the flow of signals. These diagrams show a link between the different components. Unlike purely abstract mathematical repression, the block diagram has the advantage of more realistically pointing to the flow of signals from the real system. In the all system variables are linked to each other by functional blocks. A functional block or just a block is a symbol representing a mathematical operation that forces the unit to exit above the input signal. Component transfer functions are usually included in the corresponding blocks, which are connected by arrows to indicate the direction of the signal flow. Note that the signal can only be transmitted in the direction of the shooter. Thus, the control unit scheme clearly displays a one-way property. Figure 2-1 shows an item on the block diagram. The arrow tip the block points to indicates the entrance, and the arrow that is moving away from the block represents the exit. Such arrows are known as signals. Figure 2-1. Elements of the block chart. 29. 18 Modern Engineering Management notes that the size of the output unit is the size of the input, multiplied by the size of the transmission function in the block. The advantage of presenting system block diagrams is that it's easy to form a common system-wide block by simply plugging the component block according to the signal flow and that you can evaluate the counter-bution of each component with the overall performance of the system. Typically, the functional performance of the system is easier to see by studying the block diagram than by revising the physical system itself. The block diagram contains information related to dynamic behavior, but does not include information about the physical design of the system. As a result, many different and unrelated systems can be represented by the same block diagram. It should be noted that the main power source is not clearly displayed on the block chart and that the block diagram of that system is not unique. You can draw several different block diagrams for the system, depending on the analysis's point of view. The amount of the point. Referring to the picture 2-2, the circle with the cross is a symbol indicating the amount of the operation. The plus or minus sign on each arrow tip indicates whether to add or subtract the signal. It is important that added or deductible quantities are the same size and units. Figure 2-2. The amount of the point. The branch point. A branch point is the point from which a block signal simultaneously moves to other blocks or summarizes scores. A diagram of a closed loop block. Figure 2-3 shows an example of a closed-loop system flea diagram. Exit C (s) is allocated at the point of the amount, where it is compared to the reference entry R (s). The nature of the closed loop system is indicated clarity in the picture. The output of the block, C (s) in this case, is obtained by multiplying the G transmission function (s) by entering the block, E (s). Any linear control system can be represented by a flea chart consisting of points of the amount of puns, blocks and branches. When you highlight the output at the point of the amount that needs to be matched with the input, you need to convert the output form into the input form. For example, in the temperature control system, the output signal is usually a controlled temperature. A output signal that has a temperature dimension must be converted into force, position or voltage before it can be compared to the input. This conversion is achieved by a feedback element whose transmission function is H (s), as shown in figure 2-4. The feedback element function is to change the output before comparing it to the input. (In most cases, the feedback element is a sensor that measures the output of the plant. In this example, the feedback signal returning to the point of the amount for comparison with the input is B (s)%H (s)C (s)C (s). Chapter 2. Chapter 2. Mathematical simulation of control systems 19 Figure 2-3. A diagram of a closed loop block. Figure 2-4. Closed cycle system. Open loop transmission function and direct path transmission function. Referring to Figure 2-4, the ratio of feedback B (s) between the E error signal (s) is called the open loop transmission function. That is, the open loop function of % B (s) E (s)%G (s)H (s) Ratio between exit C (s) and error signal E (s) is called direct path transmission function, thus, direct-track transmission function % C (s) E (s)%G (s) If the transmission function of the H feedback (s) is a unit, the function of direct transmission of the open cycle and the function of direct transmission are the same. A closed-loop transmission function. For the system shown in figure 2-4, exit C (s) and entry R (s) are related as: C (s)%G (s)E (s) E (s)%R (s). B (s) %R (s). H(s)C (s) If E (s) are removed from these equations, C (s)%G (s) is obtained. H (s)C (s) or C (s) R (s)% G (s) 1! G(s)H (s) (2-3) Transmission function, which refers to C (s) to R (s) is called a closed loop transmission function. This transmission function links the dynamics of the closed loop system with the dynamics of direct and feedback elements. From the equation (2-3), C (s) turns C (s)% G (s) 1! G(s)H (s) R (s) 31. 20 Modern Management Engineering Thus, the output of a closed loop system clearly depends on both the function in a closed loop by the nature of the entrance. Get cascading, parallel, and real transmission functions (in a closed loop) with MATLAB. When analyzing control systems, it is often necessary to calculate cascading transmission functions, parallel related transmission functions, and real (closed cycles) transmission functions. MATLAB performs the appropriate functions to produce cascading, parallel, and re-run (closed loop) functions. Suppose there are two G1 (s) and G2 components (s) linked differently, as shown in figure 2-5 (a), (b) and (c), where G1 (s)% num1 den1 , G2(s)% num2 den2 To obtain cascading system transmission functions, in parallel or re-lying (closed cycle) use the following operators: num,den%series (num1,den1,num2,den2) num,den%parallel (num1,den1,num2,den2) num,den% feedback (num1,den1,num2,den2) As an example, it is considered the case when G1 (s)% 10 s2!2s!10% num1 den1 , G2 (s)% 5 s!5% num2 den2 Program 2-1 in MATLAB calculates C (s)/R/R/s)%num/den for each G1 situation (G1 (den) for each G1 situation (G1 (den) s) and G2 (s). Please note that the printsys (num,den) statement displays the num/den function (i.e. C/s)/R (s). Parallel system; (c) Re-x supported the system (closed loop). Chapter 2. Mathematical Simulation Of Control Systems 21 MATLAB Program 2-1 num1%; den1%»1 2 10»; num2%;0 5; den2%; «num, den»%series (num1,den1,num2,den2); printsys (num,den) num/den% 50 sp3!7sp2!20s!50 (num, den'%parallel (num1,den1,num2,den2); printsys (num,den) num/den% 5sp2!20s!100 sp3!7sp2!20s!50 (num den'%feedback (num1,den1,num2,den2); printsys (num,den) num/den% 10s!50 sp3!7sp2!20s!100 Automatic drivers. The automatic controller compares the actual value of the plant sa-lida with the reference input (desired value), determines the deviation and duplicates the control signal, which reduces the deviation to zero or a small value. Figure 2-6 is a blocky circuitry of an industrial control system consisting of an automatic controller, drive, plant and sensor (measuring elements). consisting of an automatic controller, drive, plant and sensor (measurement element). 33. Modern engineering management equipment is being enhanced to a fairly high level. The automatic controller is powered by a drive such as a pneumatic engine or valve, hydraulic engine or electric motor. (The actuator is a power device that makes the entrance to the plant according to the control signal, so that the output signal reference input.) A sensor, or measuring element, is a device that converts a output variable into another controlled variable, such as displacement, pressure, or voltage, that can be used to compare output with a reference input. This element is in the system's feedback path in a closed loop. The controller's set point should be converted into a reference input with the same units as the sen-sor feedback signal or measurement element. Classification of industrial controllers. Industrial controllers are classified according to their control actions, such as: 1. Two positioned or off controllers 2. Proportional controllers 3. Integral controllers 4. Proportional-integral controllers 5. Proportionately-derived controllers 6. Proportional-integral derivative controllers Most industrial controllers use electricity or liquid under pressure, such as oil or air, as an energy source. Controllers can also be classified, depending on the type of energy they use in their work, such as pneumatic, hydraulic or electro-kos. The type of controller used should be decided based on the nature of the plants and operating conditions, including safety, cost, availability, reliability, accuracy, weight and size. Two-position control or shutdown/off. In the two-position management system, the current element has only two fixed positions, which in many cases are simply turned off and off. Double control or switching is relatively simple and inexpensive, so its use is widespread in both industrial and internal control systems. Suppose that the output signal of the controller is u(t) and that the signal is about an e/t error. In two provisions, the control of u(t) signal remains at a value that is maximum or minimal, indicating whether the error signal is positive or negative. Thus, u(t)%U1, for e(t)b0 %U2, for e't'a0, where U1 and U2 are permanent. Typically, the minimum U2 value is zero or. U1. It is common for two position controllers to be electrical devices, in which case an electric valve operated by the solenoids is widely used. Pneumatic controllers provide them with a very high profit function as two position controllers and are sometimes referred to as two positions of pneumatic controllers. Figures 2-7 (a) and b) show blocks diagrams for two controller positions. The range in which the error signal must be moved before switching- 34 occurs. Chapter 2. Mathematical simulation of control systems 23 Figure 2-7. (a) The switch off controller lock scheme; (b) Block chart of the differential jump controller. called a break Figure 2-7 (b) shows the differential gap. This gap causes the u(t) controller to remain in its current value until the error signal moves a little beyond zero. In some cases, the differential gap is the result of unintentional friction and lost movement; however, with fre-cuencia it is intentionally provoked to avoid too frequent me-canism operation on and off. Consider the fluid level control system at figure 2-8 (a), where the electromagnetic valve at figure 2-8 (b) is used to control the flow of inputs. This valve is open or closed. With this two controls, the water flow entrance is positive or zero constan-te. As shown in Figure 2-9, the output signal moves continuously between the two required limitations and causes the current element to move from one fixed position to another. Note that the exit curve follows one of the two curves of the exhibitor - Figure 2-8. (a) Fluid level control system; (b) Electromagnetic valve. Figure 2-9. The h(t) vs. t for the system shown in figure 2-8(a). 35. les, one of which corresponds to the fill curve and the other is the curve of the shell. This fluctuation of output between the two limitations is a general reaction to the system, which is controlled by the two provisions. Figure 2-9 shows that to reduce the amplitude of output fluctuations, differential gap must be reduced. However, reducing the differential gap increases the number of switches per minute and shortens the life of the compo-nel. The extent of the differential gap should be determined on the basis of considerations such as the required accuracy and lifespan of components. Proportional control action. For a controller with proportional control action, the link between the exit of the u/t controller and the e/t error signal is: u/t)%Kpe (t) or in quantities converted by Laplace, U (s) E (s)%Kp, where Kp is considered a proportional gain. Whatever the actual mechanism and shape of the operating power, the proportional controller is, in fact, an amplifier with an adjustable win. Comprehensive controls. In an integral control controller, the u/t output value is changed to a cause proportional to the e/t error signal. That is, du(t) dt %Kie (t) or u(t)%Ki It 0 e(t) dt, where Ki is an adjustable constant. The integral controller transfer function is U (s) E(s)% Ki s Proportional-integral control action. The control action of the pro-portion integral (PI) controller is determined by u(t)%Kpe (t)! Kp Ti It 0 e(t) dt 24 Modern Engineering Control Technology 36. Chapter 2. Mathematical simulation of control systems 25 or the transmission function of the U controller (s) 1 Ti sB, where you are called all-to-end time. Proportionately-derivative management action. The control action of the proportional-derived controller (PD) is determined by u(t)%Kpe (t)! KpTd (t) dt and transmission function U (s) E (s)%Kp (1! Td s), where Td is a derivative of time. Proportionately integral derivative controls. The combination of proportional control action, integrated control and derivative control is a de one on a proportional-integral derivative control action. This combined action has the advantages of each of the three separate control actions. The controller equation with this combined action is given u(t)%Kpe (t)! Kp Ti It 0 e(t) dt! KpTd de(t) dt or transmission function U (s) E (s)%KpA1! 1 Ti s ! TdsB, where Kp is a proportional win, you are an integral time, and Td is a derivative time. The block scheme of the proportionally-integral-derivative controller is displayed in Figu-ra 2-10. Figure 2-10. Block chart of a proportional-integral-derivative controller. A closed loop system prone to interference. Figure 2-11 shows a closed-loop system that is prone to disruption. When two inputs (reference input and violation) are presented in a linear system, each of them can be 37. 26 Modern Engineering Technology Management Figure 2-11. A closed cycle system prone to interference. On their own; and the results corresponding to each input can be added together to get a full output. How each entry is entered into the system is displayed at the point of the amount of the plus or minus mark. Consider the system shown in figure 2-11. Studying the effect of D (s) pertur-bation, we can assume that the system is initially relaxed, with zero error; you can only calculate the CD response (s) for the violation. This answer can be found with CD (s) D (s) % G2 (s) 1! G1 (s)G2(s)H(s) On the other hand, if the response to the reference entry R (s) is considered, the violation can be considered zero. Cr (s) is then answered by CR (s) to the reference entry R (s) from CR (s) R (s) % G1 (s)G2 (s) 1! G1 (s)G2 (s)H (s) Response to simultaneous application of reference input and violation is required by adding two individual responses. In other words, the C (s) response obtained from the simultaneous application of reference input R (s) and D (s) violation received C (s)%CR (s)! CD (s) % G2 (s) 1! G1 (s)G2 (s)H (s) G1 (s)R (s)! D (s) Consider now the case when G1 (s)H (s)j1 and G1 (s)G2 (s)H (s)j1. In this case, the CD (s)/D (s) function is almost zero and the effect of the violation is suppressed. This is an advantage of a closed-loop system. On the other hand, the CR (s)/R (s) mode transmission function approaches 1/H (s) as profits increase This means that if G1 (s)G2(s)H(s)j1, in-tonces, the CR (s)/R (s) transmission function becomes independent of G1 (s) and G2 (s) and becomes back proportional to H (s), so variations of G1 (s) and G2 (s) do not affect the S/R (s) It's easy to see that any closed-loop system with a feedback unit, H (s)%1, tends to equal entry and exit. Chapter 2. Mathematical Simulation of Control Systems 27 Procedures for Drawing a Flea Chart. To draw a diagram of the system block, first write equations describing the di-sea behavior of each component. Laplace conversions of these equations are then accepted, suggesting that the initial conditions are zero, and each equation converted by the Laplace method is presented individually as blocks. Finally, the items are included in the full block scheme. As an example, consider the RC diagram in figure 2-12(a). The equations for cir-cuito are i% ei.e0 R (2-4) eo% : i dt C (2-5) Laplace converts equations (2-4) and (2-5), with initial conditions equal to zero, lead to I (s)% Ei (s). Eo (s) R (2-6) Eo (s)% I (s) Cs (2-7) Equation (2-6) is an amount operation, and the corresponding chart is shown in figure 2-12 (b). The equation (2-7) represents a block in figure 2-12 (c). The integration of these two elements results in a common block pattern for the system, as shown in Figure 2-12 (d). Reduce the block chart. It's important to note that blocks can only be connected in a series if the block input is not dependent on the next block. If there are load effects between the components, you need to combine them into one block. Any number of cascading blocks representing unloaded components can be used by a single block, the transmission function of which is simply a product of individual transmission functions. Figure 2-12. (a) RC scheme; (b) Block diagram of the equation (2-6); (c) Block diagram of the equation (2-7); (d) RC chain block diagram. The complex block scheme, which contains many feedback loops, is simplified by step-by-step reordering. Simplifying the reordering and replacing the me-diante block circuit significantly reduces the work required for subsequent mathematical analysis. It should be noted, however, that as blocks are simplified, the transmission functions of new blocks become more complex as new poles and zeros are generated. EXAMPLE 2-1 Consider the system shown in figure 2-13(a). Simplify this diagram. If you move the amount of negative feedback point containing H2 from the loop H1, figure 2-13 (b) received. Removing the positive selection cycle results in figure 2-13 (c). Removing the loop containing H2/G1 occurs from figure 2-13 (d). Finally, deleting the feedback loop results in figure 2-13 (e). R G1 H1 H2 G2 G3 R R G1 H2 G1 G1 G2 G3 C G3 C C C (a) (b) (d) (e) H2 G1 G1G2 1 - G G1G2H1 G1G2G3 1 - G1G2H1 - G2G3H2 G1G2G3 1 - G1G2H1 - G2G3H2 - G1G2G3 . (a) A multi-cycle system; (b)-e) sequential abbreviation of the block chart shown in a. 28 Modern engineering equipment control 40. Chapter 2. Mathematical Simulation of Control Systems 29 Note that the C (s)/R (s) holoding function is a direct transmission function. The denominator C(s)/R (s) is 1!; (product of transferring functions around each cycle) %1! (. G1G2H1! G2G3H2! G1G2G3) %1.G1G2H1! G2G3H2! G1G2G3 (Positive Feedback Cycle Leads to a Negative Term in the Denominator.) 2-4 Modeling in public space This section presents an introductory material on the analysis of management systems in the public space. Modern management theory. The current trend in engineering systems is more complex, mainly because more complex tasks and good accuracy are required. Complex systems can have multiple inputs and multiple outlets and can be options over time. Due to the need to meet increasingly demanding requirements in the conduct of control systems, increased system complexity and easy access to large-scale computers, modern management theory, which is a new approach to the analysis and design of complex management systems, has been developed since 1960. This new approach is based on the concept of the State. The very concept of the state is not new, as it has existed for quite a long time in the field of classical dynamics and in other areas. Modern management theory versus conventional management theory. The current management trend contrasts with the traditional theory of governance in the sense that its formulation applies to multi-vector multiprophytic systems that may be linear or non-linear, time-imaginants or variables over time, while traditional theory applies only to input inarinate systems over time. In addition, modern management theory is essentially an approximation in the temporal area, while traditional management theory is an approximation in the area of complex frequency. The variable states, the state vector and the state space must be defined before conti-nuar. State. The state of the dynamic system is the smallest set of variables (so-called state variables), so knowledge of these variables in t%t0, along with the input of knowledge for tnt0, fully determine the behavior of the system-ma in any tnt0. Note that the concept of state is not limited to physical systems. It applies to more biological systems, economic systems, social systems and others. State variables. Variables in a dynamic system are variables that constipate-tuyen the smallest set of variables that determine the state of a dynamic system. If at least n variables x1, x2, ... xn are needed to fully describe the behavior of the dynamic system-ma (so that once the input for tnt0 has been given and the initial state in t%t0 has been indicated, the future state of the system is fully defined), then such n variables are a set of variable states. State. teoria de control moderna ogata. teoria de control moderno ogata pdf. teoria de control moderno ogata