



# Digital (Discrete-Time) Control Systems

## E1541 Introduction to Digital Control Systems

Lec. #01

Prof. Dr. Walaa Gabr

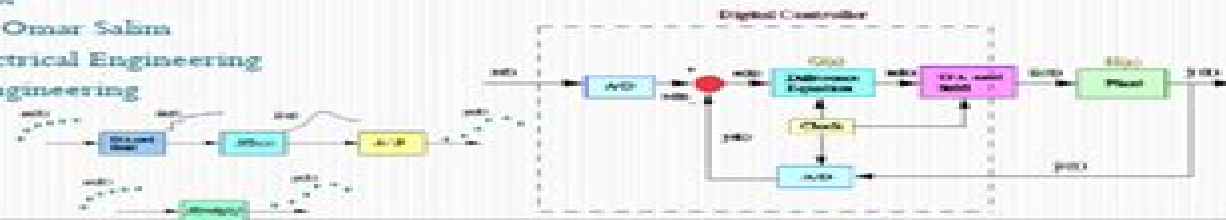
Associate Prof. Dr. Omar Salim

Department of Electrical Engineering

Benha Faculty of Engineering

Benha University

Oct. 2023



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### Lecture Agenda:-

- Intro. to the “Digital Control Systems (DCS)” Course
  - Course Aims
  - Course Intended Learning Outcomes ILOs.
  - Course Syllabus
  - Course Grading
  - Course References
- Why Digital Control?
- Advantages for DCS
- Types of signals
- The Structure of a Digital Control System
- References.

10/11/2023

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# Introduction To Digital Control System

**Ioan Doré Landau, Gianluca Zito**



## **Introduction To Digital Control System:**

*Introduction to Digital Control Systems* Hugh F. VanLandingham, 1985      *Introduction to Continuous and Digital Control Systems* Roberto Saucedo, Earl E. Schiring, 1968      *Industrial Digital Control Systems* K. Warwick, D. Rees, 1988 Includes Digital signals and systems Digital controllers for process control applications Design of digital controllers Control of time delay systems State space concepts System identification Introduction to discrete optimal control Multivariable control Adaptive control Computer aided design for industrial control systems Reliability and redundancy in microprocessor controllers Software and hardware aspects of industrial controller implementations Application of distributed digital control algorithms to power stations An expert system for process control      *INTRODUCTION TO LINEAR AND DIGITAL CONTROL SYSTEMS* ARUN K. GHOSH, 2007-05-02 This book presents comprehensive coverage of linear control systems along with an introduction to digital control systems It is designed for undergraduate courses in control systems taught in departments of electrical engineering electronics and instrumentation electronics and communication instrumentation and control and computer science and engineering The text discusses the important concepts of control systems transfer functions and system components It describes system stability employing the Hurwitz Routh stability criterion root locus technique Bode plot and polar and Nyquist plots In addition this student friendly book features in depth coverage of controllers compensators state space modelling and discrete time systems KEY FEATURES Includes a brief tutorial on MATLAB in an appendix to help students learn how to use it for the analysis and design of control systems Provides an abundance of worked out examples and review questions culled from university examination papers Gives answers to selected chapter end questions at the end of the book      **Digital Control Engineering** M. Gopal, 1988      **Digital Control Systems** Ioan Doré Landau, Gianluca Zito, 2007-05-11 The extraordinary development of digital computers microprocessors microcontrollers and their extensive use in control systems in all fields of applications has brought about important changes in the design of control systems Their performance and their low cost make them suitable for use in control systems of various kinds which demand far better capabilities and performances than those provided by analog controllers However in order really to take advantage of the capabilities of microprocessors it is not enough to reproduce the behavior of analog PID controllers One needs to implement specific and high performance model based control techniques developed for computer controlled systems techniques that have been extensively tested in practice In this context identification of a plant dynamic model from data is a fundamental step in the design of the control system The book takes into account the fact that the association of books with software and on line material is radically changing the teaching methods of the control discipline Despite its interactive character computer aided control design software requires the understanding of a number of concepts in order to be used efficiently The use of software for illustrating the various concepts and algorithms helps understanding and rapidly gives a feeling of the various phenomena      **Introduction to Applied Digital Controls** Gregory Starr, 2020-06-29 This textbook introduces

senior undergraduate and beginning graduate students of mechanical engineering to the field of digital control with an emphasis on applications Both transform based and state variable approaches are included with a brief introduction to system identification The material requires some understanding of the Laplace transform and assumes that the reader has studied linear feedback control systems Adopting an accessible tutorial format the text presents a clear and concise treatment of Linear Difference Equations Discrete Simulation of Continuous Systems Sampled Data Systems Design using Laplace and Z Transforms Introduction to Continuous State Space Digital Control Design using State Space Methods including state estimators and System Identification using Least Squares      **Digital Control Systems** Ioan Doré

Landau, Gianluca Zito, 2005-10-13 The extraordinary development of digital computers microprocessors microcontrollers and their extensive use in control systems in all fields of applications has brought about important changes in the design of control systems Their performance and their low cost make them suitable for use in control systems of various kinds which demand far better capabilities and performances than those provided by analog controllers However in order really to take advantage of the capabilities of microprocessors it is not enough to reproduce the behavior of analog PID controllers One needs to implement specific and high performance model based control techniques developed for computer controlled systems techniques that have been extensively tested in practice In this context identification of a plant dynamic model from data is a fundamental step in the design of the control system The book takes into account the fact that the association of books with software and on line material is radically changing the teaching methods of the control discipline Despite its interactive character computer aided control design software requires the understanding of a number of concepts in order to be used efficiently The use of software for illustrating the various concepts and algorithms helps understanding and rapidly gives a feeling of the various phenomena      **Direct Digital Control Systems** Mary S. Nardone, 2012-12-06

**Digital Control Systems** Application Commissioning offers an insightful examination of the critical role of the DDC system in the commissioning process Included is solid coverage of microprocessor based control systems combined with the protocols and procedures needed to effectively integrate DDC system validation into systems commissioning This field handbook is an everyday reference on Direct Digital Control for commissioning personnel Whether designer contractor air balancer technician vendor commissioning agent owner operator or student increasing one's knowledge of DDC control systems will directly improve project performance      **Digital Control Systems** Anastasia Veloni, Nikolaos Miridakis, 2017-08-07 The objective of this book is to provide a collection of solved problems on control systems with an emphasis on practical problems System functionality is described the modeling process is explained the problem solution is introduced and the derived results are discussed Each chapter ends with a discussion on applying MATLAB LabVIEW and or Comprehensive Control to the previously introduced concepts The aim of the book is to help an average reader understand the concepts of control systems through problems and applications The solutions are based directly on math formulas given in extensive tables

throughout the text     **Modern Digital Control Systems** Raymond G. Jacquot, 2019-01-22 This work presents traditional methods and current techniques of incorporating the computer into closed loop dynamic systems control combining conventional transfer function design and state variable concepts Digital Control Designer an award winning software program which permits the solution of highly complex problems is available on the CR     **Digital Control Systems** Benjamin C. Kuo, 1995-06 In recent years significant progress has been made in the analysis and design of discrete data and digital control systems These systems have gained popularity and importance in industry due in part to the advances made in digital computers for controls and more recently in microprocessors and digital signal processors An introductory text for a senior or graduate course on digital control systems this text covers the theory and applications of digital control systems assuming a knowledge of matrix algebra differential equations Laplace transforms and the basic principles of continuous data control systems Many subjects are new to the Second Edition most importantly design topics such as disturbance rejection sensitivity considerations and zero ripple deadbeat response design In addition Kuo includes separate discussions on controllability observability and stability expands the discussions of sampling period selection emphasizes computer aided solutions and provides a new and simpler approach to the Nyquist criterion of stability Each chapter begins with keywords and topics that provide students with an overview of the key topics to be covered Illustrative examples many derived from practical systems are included throughout the text Numerous exercise problems end each chapter     **Control System Fundamentals** William S. Levine, 2019-01-15 Sifting through the variety of control systems applications can be a chore Diverse and numerous technologies inspire applications ranging from float valves to microprocessors Relevant to any system you might use the highly adaptable Control System Fundamentals fills your need for a comprehensive treatment of the basic principles of control system engineering This overview furnishes the underpinnings of modern control systems Beginning with a review of the required mathematics major subsections cover digital control and modeling An international panel of experts discusses the specification of control systems techniques for dealing with the most common and important control system nonlinearities and digital implementation of control systems with complete references This framework yields a primary resource that is also capable of directing you to more detailed articles and books This self contained reference explores the universal aspects of control that you need for any application Reliable up to date and versatile Control System Fundamentals answers your basic control systems questions and acts as an ideal starting point for approaching any control problem     **The Control Handbook** William S. Levine, 2017-12-19 At publication The Control Handbook immediately became the definitive resource that engineers working with modern control systems required Among its many accolades that first edition was cited by the AAP as the Best Engineering Handbook of 1996 Now 15 years later William Levine has once again compiled the most comprehensive and authoritative resource on control engineering He has fully reorganized the text to reflect the technical advances achieved since the last edition and has expanded its contents to include the

multidisciplinary perspective that is making control engineering a critical component in so many fields Now expanded from one to three volumes The Control Handbook Second Edition brilliantly organizes cutting edge contributions from more than 200 leading experts representing every corner of the globe The first volume Control System Fundamentals offers an overview for those new to the field but is also of great value to those across any number of fields whose work is reliant on but not exclusively dedicated to control systems Covering mathematical fundamentals defining principles and basic system approaches this volume Details essential background including transforms and complex variables Includes mathematical and graphical models used for dynamical systems Covers analysis and design methods and stability testing for continuous time systems Delves into digital control and discrete time systems including real time software for implementing feedback control and programmable controllers Analyzes design methods for nonlinear systems As with the first edition the new edition not only stands as a record of accomplishment in control engineering but provides researchers with the means to make further advances Progressively organized the other two volumes in the set include Control System Applications Control System Advanced Methods

Digital Control Systems Rolf Isermann, 2013-11-11 This well known book is an introduction to the field of digital sampled data control It treats the field in depth and can be used for courses and for self study The second edition has been completely revised and expanded with new results The work now appears in two volumes with Volume 2 to be published in 1989 The volumes form a unit and take the reader systematically from fundamentals to problems of real applications The work is directed towards students of electrical and mechanical engineering computer science especially with a specialization on automation and control engineering and other fields like biology economics space mathematics and physics It is also directed to engineers and scientists concerned with solving concrete problems

**Control Systems, 3e** S. K. Bhattacharya, 2013 The book has been designed to cover the complete syllabi of Control Systems taught during various engineering courses at the undergraduate level It would also help students appearing for competitive examinations like GATE IAS IES NTPC and NHPC The topics are explained in a simple and lucid manner with the help of extended derivations accompanied by an exhaustive number of new figures illustrations and solved examples Practical applications along with the explanation of key concepts are included

Digital Power Electronics and Applications Fang Lin Luo, Hong Ye, Muhammad H. Rashid, 2010-07-20 The purpose of this book is to describe the theory of Digital Power Electronics and its applications The authors apply digital control theory to power electronics in a manner thoroughly different from the traditional analog control scheme In order to apply digital control theory to power electronics the authors define a number of new parameters including the energy factor pumping energy stored energy time constant and damping time constant These parameters differ from traditional parameters such as the power factor power transfer efficiency ripple factor and total harmonic distortion These new parameters result in the definition of new mathematical modeling A zero order hold ZOH is used to simulate all AC DC rectifiers A first order hold FOH is used to simulate all DC AC inverters A second order hold SOH is used to simulate

all DC DC converters A first order hold FOH is used to simulate all AC AC AC DC AC converters Presents most up to date methods of analysis and control algorithms for developing power electronic converters and power switching circuits Provides an invaluable reference for engineers designing power converters commercial power supplies control systems for motor drives active filters etc Presents methods of analysis not available in other books

**MODERN CONTROL ENGINEERING**  
D. ROY CHOUDHURY, 2005-01-01 This book represents an attempt to organize and unify the diverse methods of analysis of feedback control systems and presents the fundamentals explicitly and clearly The scope of the text is such that it can be used for a two semester course in control systems at the level of undergraduate students in any of the various branches of engineering electrical aeronautical mechanical and chemical Emphasis is on the development of basic theory The text is easy to follow and contains many examples to reinforce the understanding of the theory Several software programs have been developed in MATLAB platform for better understanding of design of control systems Many varied problems are included at the end of each chapter The basic principles and fundamental concepts of feedback control systems using the conventional frequency domain and time domain approaches are presented in a clearly accessible form in the first portion chapters 1 through 10 The later portion chapters 11 through 14 provides a thorough understanding of concepts such as state space controllability and observability Students are also acquainted with the techniques available for analysing discrete data and nonlinear systems The hallmark feature of this text is that it helps the reader gain a sound understanding of both modern and classical topics in control engineering

Digital Control Engineering M. Sami Fadali, Antonio Visioli, 2012-09-06 Digital controllers are part of nearly all modern personal industrial and transportation systems Every senior or graduate student of electrical chemical or mechanical engineering should therefore be familiar with the basic theory of digital controllers This new text covers the fundamental principles and applications of digital control engineering with emphasis on engineering design Fadali and Visioli cover analysis and design of digitally controlled systems and describe applications of digital controls in a wide range of fields With worked examples and Matlab applications in every chapter and many end of chapter assignments this text provides both theory and practice for those coming to digital control engineering for the first time whether as a student or practicing engineer Extensive Use of computational tools Matlab sections at end of each chapter show how to implement concepts from the chapter Frees the student from the drudgery of mundane calculations and allows him to consider more subtle aspects of control system analysis and design An engineering approach to digital controls emphasis throughout the book is on design of control systems Mathematics is used to help explain concepts but throughout the text discussion is tied to design and implementation For example coverage of analog controls in chapter 5 is not simply a review but is used to show how analog control systems map to digital control systems Review of Background Material contains review material to aid understanding of digital control analysis and design Examples include discussion of discrete time systems in time domain and frequency domain reviewed from linear systems course and root locus design in s domain

and z domain reviewed from feedback control course Inclusion of Advanced Topics In addition to the basic topics required for a one semester senior graduate class the text includes some advanced material to make it suitable for an introductory graduate level class or for two quarters at the senior graduate level Examples of optional topics are state space methods which may receive brief coverage in a one semester course and nonlinear discrete time systems Minimal Mathematics Prerequisites The mathematics background required for understanding most of the book is based on what can be reasonably expected from the average electrical chemical or mechanical engineering senior This background includes three semesters of calculus differential equations and basic linear algebra Some texts on digital control require more

Optimum Design of Digital Control Systems by Julius T Tou ,1963-01-01 In this book we study theoretical and practical aspects of computing methods for mathematical modelling of nonlinear systems A number of computing techniques are considered such as methods of operator approximation with any given accuracy operator interpolation techniques including a non Lagrange interpolation methods of system representation subject to constraints associated with concepts of causality memory and stationarity methods of system representation with an accuracy that is the best within a given class of models methods of covariance matrix estimation methods for low rank matrix approximations hybrid methods based on a combination of iterative procedures and best operator approximation and methods for information compression and filtering under condition that a filter model should satisfy restrictions associated with causality and different types of memory As a result the book represents a blend of new methods in general computational analysis and specific but also generic techniques for study of systems theory and its particular branches such as optimal filtering and information compression Best operator approximation Non Lagrange interpolation Generic Karhunen Loeve transform Generalised low rank matrix approximation Optimal data compression Optimal nonlinear filtering

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