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CHAPTER 6

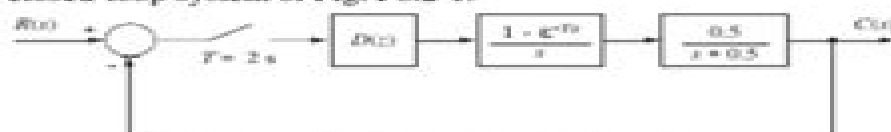**6.2-1.** Consider the closed-loop system of Fig. P6.2-1.

Figure P6.2-1 System for Problem 6.2-1.

(a) Calculate and plot the unit-step response at the sampling instants, for the case that $D(z) = 1$.

(b) Calculate the system unit-step response of the analog system, that is, with the sampler, digital controller, and data hold removed. Plot the response on the same graph with the results of part (a).

(c) For the system of Fig. P6.2-1, let $D(z) = 1$ and $T = 0.4$ s. Calculate the unit-step response and plot these results on the same graph used for parts (a) and (b).

(d) Use the system dc gains to calculate the steady-state responses for each of the systems of parts (a), (b), and (c). Why are these gains equal?

Solution:

(a) $\quad G(z) = \dfrac{z-1}{z} \mathscr{Z}\left[\dfrac{0.5}{s(s+0.5)}\right] = \dfrac{z-1}{z} \dfrac{(1-\varepsilon^{-1})}{(z-1)(z-\varepsilon^{-1})} = \dfrac{0.6321}{z-0.3679}$

$\dfrac{G(z)}{1+G(z)} = \dfrac{0.6321}{z-0.2642}$

$C(z) = \dfrac{0.6321}{\quad} = \dfrac{0.5}{\quad} + \dfrac{-0.5}{\quad}$

Control Engineering Digital Analysis

SA Adler

Control Engineering Digital Analysis :

Digital Control Engineering M. Sami Fadali,Antonio Visioli,2012-08-21 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 **Digital Control Engineering** M. Gopal,1988 *Digital Control Systems* Constantine H. Houpis,Gary B. Lamont,1992 Continuous time control system response characteristics Linear systems and the sampling process Discrete systems modeling Discrete control analysis Discrete transform analysis approximations Principles of signal conversion and measurement Digital control system implementation Random processes in digital control systems Finite word lenght and compensator structure Cascade compensation digitization DIG technique Cascade compensation direct DIR technique Feedback compensation Discrete state variable model State space design methods Discrete quantitative feedback technique Modern discrete control theory Discrete optimal control Discrete estimation and stochastic control Fourier transform Convolution Pade approximation Power series Computer Aided Design

CAD programs for control Matrix manipulations Signal flow graphs w Transformation characteristics Number representations Theory of probability Discrete QFT design processes   <u>Digital Control Systems</u> Ioan Doré Landau,Gianluca Zito,2009-10-12 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 Digital Control* Biswanath Samanta,2024-10-17 This textbook presents an integrated approach to digital discrete time control systems covering analysis design simulation and real time implementation through relevant hardware and software platforms Topics related to discrete time control systems include z transform inverse z transform sampling and reconstruction open and closed loop system characteristics steady state accuracy for different system types and input functions stability analysis in z domain Jury s test bilinear transformation from z to w domain stability analysis in w domain Routh Hurwitz criterion root locus techniques in z domain frequency domain analysis in w domain control system specifications in time and frequency domains design of controllers PI PD PID phase lag phase lead phase lag lead using time and frequency domain specifications state space methods controllability and observability pole placement controllers design of observers estimators full order prediction reduced order and current observers system identification optimal control linear quadratic regulator LQR linear quadratic Gaussian LQG estimator Kalman filter implementation of controllers and laboratory experiments for validation of analysis and design techniques on real laboratory scale hardware modules Both single input single output SISO and multi input multi output MIMO systems are covered Software platform of Matlab Simulnik is used for analysis design and simulation and hardware software platforms of National Instruments NI LabVIEW are used for implementation and validation of analysis and design of digital control systems Demonstrating the use of an integrated approach to cover interdisciplinary topics of digital control emphasizing theoretical background validation through analysis simulation and implementation in physical laboratory experiments the book is ideal for students of engineering and applied science across in a range of concentrations   **Introduction to**

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introduction describes examples of sampled data systems in particular digital controllers and analyzes the sampler and hold also some design aspects are introduced Chapter 2 reviews the modelling and analysis of continuous systems Pole shifting is formulated as an affine mapping here some n w material on fixing some eigenvalues or some gains in a design step is included Chapter 3 treats the analysis of sampled data systems by state space and z transform methods This includes sections on inter sampling behavior time delay systems absolute stability and non synchronous sampling Chapter 4 treats controllability and reach ability of discrete time systems controllability regions for con strained inputs and the choice of the sampling interval primarily under controllability aspects Chapter 5 deals with observability and constructability both from the discrete and continuous plant output Full and reduced order observers are treated as well as disturbance observers

Design and Analysis of Control Systems Arthur G.O. Mutambara,2024-03-27 Written to inspire and cultivate the ability to design and analyse feasible control algorithms for a wide range of engineering applications this comprehensive text covers the theoretical and practical principles involved in the design and analysis of control systems This second edition introduces 4IR adoption strategies for traditional intelligent control including new techniques of implementing control systems It provides improved coverage of the characteristics of feedback control root locus analysis frequency response analysis state space methods digital control systems and advanced controls including updated worked examples and problems Features Describes very timely applications and contains a good mix of theory application and computer simulation Covers all the fundamentals of control systems Takes a transdisciplinary and cross disciplinary approach Explores updates for 4IR Industry 4 0 and includes better experiments and illustrations for nonlinear control systems Includes homework problems case studies examples and a solutions manual This book is aimed at senior undergraduate and graduate students professional engineers and academic researchers in interrelated engineering disciplines such as electrical mechanical aerospace mechatronics robotics and other AI based systems **Nuclear Science Abstracts** ,1974 NSA is a comprehensive collection of international nuclear science and technology literature for the period 1948 through 1976 pre dating the prestigious INIS database which began in 1970 NSA existed as a printed product Volumes 1 33 initially created by DOE s predecessor the U S Atomic Energy Commission AEC NSA includes citations to scientific and technical reports from the AEC the U S Energy Research and Development Administration and its contractors plus other agencies and international organizations universities and industrial and research organizations References to books conference proceedings papers patents dissertations engineering drawings and journal articles from worldwide sources are also included Abstracts and full text are provided if available

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web description this fault code sets when the aftertreatment control module acm detects that the nox conversion is lower than a calibrated threshold monitored parameter selective catalyst reduction scr inlet nox sensor scr outlet

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web jun 8 2019   section 28 1 1 verify repairs check as follows turn ignition off reconnect any electrical connections that were disconnected to perform the diagnosis clear codes with dddl 7 0 or latest version engine exhaust to avoid injury from inhaling engine exhaust always operate the engine in a well ventilated area engine exhaust is toxic

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web detroit diesel dd13 and dd15 service manual 13 the coolant level sensor is defective wires or connectors 14 the coolant level sensor is defective wires or connectors 14 the oil temperature sensor wires or connectors are faulty 15 defective temperature sensor o w or oil temperature sensor wires or connectors

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web jun 8 2019   debris entering injector intermittent faults check as follows using dddl 7 0 check for multiple codes if additional fault codes are present along with 1328 13 service the additional fault codes first if only 1328 13 is present go to next step using dddl 7 0 perform compression test listed under service routines

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web jun 8 2019   figure 1 motor control module note do not ground the mcm this can result in false codes being logged the motor control module mcm incorporates a heat exchanger which uses fuel to cool the mcm the top plate of the heat exchanger incorporates the inlet and outlet fitting for fuel supply entering and exiting the heat

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web please note the following these codes are for your reference only detroit diesel series 60 engines only codes 43 44 45 51 and 53 are critical codes and if they are shown the stop engine light will come on which causes the engine protections to engage and your engine may shut down

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web detroit dd15 epa10 2010 13 fault code spn 677 fmi 5 mcm engine starter relay open circuit description this fault sets when the mcm detects that there is an open on the engine starter relay circuit

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web 2 an upstream engine issue that effects the air fuel ratio fault code history datamining use diagnosticlink to review datamining information by going into the fault code history tab in diagnosticlink compare the fault code history codes to the list of codes in table 1 diagnosticlink log file

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web aug 12 2022   another dd15 with multiple faults that are related to regen problems spn 3480 fmi 2 doser fuel line pressure low possible doser valve or doser block issue

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web some detroit heavy duty gen 5 dd15 engines are experiencing exhaust valve bridges that fall out of position or have excessive valve lash the engine may experience conditions such as ticking rough running misfire or popping out sounds from the intake the following fault codes have been associated with this failure and may also be present

dd15 troubleshooting section 52 3 spn 625 fmi 9 detroit - May 12 2023

web jun 8 2019   start and bring engine up to operating temperature over 140 f 60 c verify operation is satisfactory and no warning lamps illuminate if warning lamps illuminate troubleshoot the codes if assistance is required call the detroit diesel customer support center at 313 592 5800

dd15 troubleshooting section 22 3 spn 91 fmi 4 detroit - Apr 11 2023

web jun 8 2019   clear codes with dddl 7 0 or latest version start and bring engine up to operating temperature over 140 f 60 c verify operation is satisfactory and no warning lamps illuminate if warning lamps illuminate troubleshoot the codes if assistance is required call the detroit diesel customer support center at 313 592 5800

dd15 troubleshooting section 111 2 spn 3510 fmi 4 detroit - Jan 08 2023

web jun 8 2019   section 111 2 1 verify repairs verify repairs as follows turn ignition off reconnect any electrical connections that were disconnected to perform the diagnosis clear codes with dddl 7 0 or latest version start and bring engine up to operating temperature over 140 f 60 c verify operation is satisfactory and no warning lamps

157 fuel rail pressure too low dd15 troubleshooting - Apr 30 2022

web the motor control module mcm monitors the rail pressure and when rail pressure deviation is greater than 200 bar for eight seconds the mcm sets the code this fault can occur due to the conditions listed below external fuel leakage between the high pressure pump and fuel injectors pressure limiting valve leakage internal

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web jun 8 2019   start and bring engine up to operating temperature over 140 f 60 c verify operation is satisfactory and no warning lamps illuminate if warning lamps illuminate troubleshoot the codes if assistance is required call the detroit diesel customer support center at 313 592 5800

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web j1939 powertrain message amt detroit transmission is missing 1121 13 j1939 service brake switch signal from ebc1 is missing or not available 1121 19 j1939 service brake switch signal from ebc1 is erratic 1237 4 stop engine override switch short circuit to ground 1243 14 abs fault restricts automatic gear selection functionality