



Introduction to Digital Communications (Second Edition)

by Joachim Speidel, Cham, Springer, 2021, 330 pp., 74.89 € (eBook), ISBN 978-3-030-00548-1; 89.99 € (Softcover), ISBN 978-3-030-13123-4

Nico Irawan, Pratiwi Retnaningdyah & Ali Mustofa

To cite this article: Nico Irawan, Pratiwi Retnaningdyah & Ali Mustofa (2022): Introduction to Digital Communications (Second Edition), Southern Communication Journal, DOI: [10.1080/1041794X.2022.2037155](https://doi.org/10.1080/1041794X.2022.2037155)

To link to this article: <https://doi.org/10.1080/1041794X.2022.2037155>



Published online: 10 Feb 2022.



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BOOK REVIEW

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This book is devoted to the fundamentals and applications of modern signal processing methods and cutting-edge communication technologies. It discusses the evolution of optical transmission and the future internet, built on wired and wireless technology for digital communication in this age. It is aimed at anyone with a great interest in current digital communications. It is primarily concerned with the principles of the physical layer as viewed through the lenses of time-variant linear systems. The theme of this book is wireless transmission over time-varying channels. While each chapter gives a numerical example of data in digital communication, the primary emphasis is on a proper mathematical explanation that shows and demonstrates the facts and lemmas. The book's core themes are information and signal theory, as well as acoustic signal processing, image processing, and multimedia systems. The book is organized into three parts and four appendices containing twenty chapters.

The first part of this book, "Digital Communication over Single Input Single Output Channels" (p. 3), discusses the fundamental concepts of digital transmission, which apply to both wired and wireless communications. This part will educate readers about the fundamental components of Single Input Single Output (SISO) systems (p. 3) in digital communication. Chapter 1 of "Quadrature Amplitude Modulation in Transmission Systems" discusses the concept of quadrature amplitude modulation. An essential step in the process (pp. 17–20) described in Chapter 2 of "Intersymbol Interference and Noise" is designing the entire system to have the least amount of intersymbol interference possible (p. 17), which is consistent with Nyquist's first criterion.

When a comparable baseband system is employed, the connection between the transmitter input and receiver output can be stated briefly as a "black box," eliminating the need to specify modulation, spectral signal shaping, or channel parameters. Chapter 3, "Detection Methods," delves deeply into a range of different detection techniques for the received signal, including threshold decision, maximum likelihood (p. 31) and most importantly, a posteriori detection. Additionally, the contrast between symbol-by-symbol and sequence-by-sequence detection is discussed (p. 37), along with an example of the maximum likelihood sequence estimator (pp. 39–41). Chapter 4 of "Digital Transmission over Wireless, Time-Variant Channels" (p. 47) has developed into an important research issue due to the great flexibility and convenience that wireless connections provide for a large number of users as demonstrated in the study. With a sufficiently precise model of the noise present at the receiver, one may estimate the probability of encountering a symbol error (p. 58).

One of the most significant properties of a single-input single-output wireless network is summarized in Chapter 5 (p. 63). Channels can be split up. The wave propagation channel separates the antenna output and receives antenna input in the inner section of the channel. The next level classifies transmitting and receiving antennas, including their emission patterns and intensities. Chapter 6, "Block-Wise Signal with/without Prefix across FIR Channels," shows how to employ Finite Impulse Response (FIR) filters from signal processing (p. 87). It also covers discrete-time input signals with a finite period defined by a signal vector, called a block of samples. The block-wise transmission technique will be explored in detail. It sets a guard gap between signal blocks and investigates their characteristics.

Frequency Division Multiplexing (FDM) is the process of splitting a frequency band into several channels using modulation. The analog telephone networks used until the 1970s are shown in Chapter 7 (p. 103). Then came digital telephony, which uses a Time Division Multiplexing (TDM) system (p. 104). So, each application gets its time period. FDM is also used to operate terrestrial, satellite, and cable television transmission networks. Nowadays, most mobile and cellular networks use both FDM and TDM. Filters have traditionally been used to carefully segregate channels in FDM schemes to prevent information cross-talk (p. 116).

The second part, “Theory of Linear Time-Variant Systems” (p. 121), has been critical in communications, owing to the emergence of wireless networks for indoor and outdoor use. The mathematical properties of time-variant convolution are discussed in Chapter 8, “Introduction and some background” (p. 121). The time-variant impulse response and the delay spread function perform admirably in the time domain and also discussed are the time-variant transfer function and the Doppler spread function (p. 123). Chapter 9, “A System Theoretic Approach to the Impulse Response of Linear Time-Variant Systems,” discusses continuous time, time-variant impulse responses (p. 125), modified time-variant impulse responses—the delay spread function (p. 128), and discrete-time, time-variant systems (p. 130), which include a discrete-time delay spread function and a transition to a continuous-time delay spread function (p. 134). Chapter 10, “Aspects of Time-Variant Convolution” (p. 137), delves into the details of several important properties of time-variant convolution. Chapter 11, “System Functions and the Fourier Transform” (p. 149), examine the time-variant impulse response and delay spread function, which perfectly characterize a linear time-variant system and are hence referred to as system functions. Finally, Chapter 12, “Randomly Changing Time-Variant Systems” (p. 165), treats time-variant systems’ signals and characteristic functions as deterministic, mainly the delay spread function. In many applications, for example, wireless communications, the time-variant channel can exhibit a wide variety of distinct properties depending on the environment, the transmitter’s or receiver’s speed, and other factors.

The third Part, “Multiple Input Multiple Output Wireless Transmission” (p. 179), discusses Multiple Input Multiple Output (MIMO) systems. To begin, the matrix notation is used to derive the input-output relation (p. 183). Chapter 13 examines the fundamentals of MIMO channel modeling, including the time-variant finite impulse response (p. 186) and the i.i.d. Gaussian MIMO channel model (p. 189). However, spatial correlations are introduced at the transmitter (p. 187) and receiver, resulting in the Kronecker model (p. 194). Next, it examines linear and nonlinear MIMO receivers in-depth, including zero-forcing, least mean squared error, and maximum likelihood receivers. A critical question in Chapter 14 is how many bits per channel can be sent using MIMO channels (p. 201). Chapters 15–18 examine the topic in conjunction with maximizing channel capacity (pp. 229–280). The ideas of spatial prefiltering and space-time encoding are next discussed in Chapter 19 (p. 281) to improve transmission quality and data rate. The final chapter, or Chapter 20 (p. 305), abandons single-user transmission in favor of the MIMO principle for networks with many users. This chapter discusses various multi-user MIMO methods for the uplink and downlink that can help reduce interference when users transmit their signals in the same time slots and frequency ranges.

This book contains an abundance of numerical data obtained from mathematical facts. As a result, reading this book benefits upgradeability and improves numerical skills. Readers inexperienced with mathematics, mainly numerical data, will, nonetheless, find this task tedious. While references do not support some notions, this book is intended for everyone who knows the concept of numerical explanation. As a result, interpreting and gleaning information from it will be uncomplicated.

Additionally, despite the difficult vocabulary in each chapter, this book supports the development of new information about digital communications in everyday life activities, particularly for communicators.

Nico Irawan

Universitas Negeri Surabaya, Indonesia

Rajamangala University of Technology Krungthep, Bangkok, Thailand

✉ nico.19001@mhs.unesa.ac.id  <http://orcid.org/0000-0002-5955-7634>

Pratiwi Retnaningdyah and Ali Mustofa

Universitas Negeri Surabaya, Indonesia  <http://orcid.org/0000-0003-2282-1953>

 <http://orcid.org/0000-0001-8755-648X>

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<https://doi.org/10.1080/1041794X.2022.2037155>

