

Preface

Here it is standing: atoms with consciousness; matter with curiosity. Stands at the sea, wondering: I . . . a universe of atoms, an atom in the universe.

Richard Feynman

While teaching classes on digital transmission and mobile communications for undergraduate and graduate students, I was wondering if it would be possible to write a book capable of giving them some insight about the practical meaning of the concepts, beyond the mathematics; the same insight that experience and repetitive contact with the subject are capable to construct; the insight that is capable of building the bridge between the theory and *how the theory manifests itself in practice*.

I remember those days when I was a graduate student at State University of Campinas (Unicamp), SP, Brazil, and those lectures given with competence by my professors. At that time, for me and for most of the students, some topics were nebulous, except by the fact that a few times we were able to follow the mathematics. Something that could translate mathematics into waveforms, block diagrams, circuits and the like was missing from the student's point of view.

Later, in 1999 I took contact with one of the first versions of VisSim/Comm, a communication's systems simulation software jointly developed by *Visual Solutions, Inc.* (<http://www.vissol.com/>) and *Eritek, Inc.* (<http://www.eritek.com/>). I started using VisSim/Comm just to help me better understand the subjects I was studying while preparing my lecture materials. Soon I realized that the software could be used in a similar way to help students to understand the concepts that I was teaching them. Then I began to use VisSim/Comm as a teaching tool, showing previously prepared simulations to the students just after the mathematical or conceptual explanation about some topic.

The students gave me very positive feedback about the idea, but insisted to claim that, unconditionally, "theory is different from practice" in what concerns communication systems. As a reply I always told them that this is an unfair judgment. Theory would produce, and sometimes actually produces the same results as actual systems, as long as the mathematical model of the system under analysis is able to take into account all or most of the relevant system variables. Theory is different from

practice in cases where it is impossible or mathematically intractable to consider all important system variables. We must live with this difference. Otherwise, we would have nothing to do. Eventually I felt that we have reached to a balance. . .

This book is the result of such experience. Discussing with my students and preparing class notes and simulations throughout these years have given to me the opportunity to resolve my past wonderings.

This is not a conventional textbook on Digital Transmission, nor a book on Simulation of Communications Systems. The literature is rich, and it is not difficult to find excellent books about these areas. Furthermore, it would be an act of arrogance to aim at preparing a book to “compete” with those from where I have learned what would be presented in such book.

This book addresses basic concepts on digital transmission, mainly pertaining to the physical layer of a digital communication system. However, these basic concepts are also intended to allow the reader to understand more advanced topics and the associated technology. Each topic is addressed in two different and complementary ways: *theoretically* and *by simulation*. The theoretical approach encompasses common subjects covering principles of digital transmission, like notions of probability and stochastic processes, signals and systems, baseband and passband signaling, signal-space representation, spread spectrum, multi-carrier and ultra wideband transmissions, carrier and symbol-timing recovery, information theory and error-correcting codes. The simulation approach also covers these subjects, but with focus on the capabilities of VisSim/Comm to help the reader *fulfill the gap between the theory and its practical meaning*. The presentation of the theory is made easier with the help of 357 illustrations. A total of 101 simulation files support the simulation-oriented approach.

Although the computer experiments can be considered themselves as exercises to test the reader’s knowledge, some additional problems are proposed inside the simulation work plans and a few more are proposed at the end of each chapter. Most of the proposed problems are simulation-oriented in the sense that the reader is guided to create specific simulations for exploring the practical meaning of concepts not explicitly covered before, for complementing those already covered, or simply for revisiting a given concept with a different perspective. A significant part of the remaining problems deals with the study of specific topics, aiming at complementing some theory.

All simulation files used throughout the book are supplied in the accompanying CD and run with an evaluation version of VisSim/Comm, which is also available in the CD. This evaluation version allows for users to run all examples included in the CD and construct new diagrams, but not save their work. Nevertheless, if the reader is able to afford a full version of VisSim/Comm, he can benefit from the opportunity of enhancing his knowledge through a deeper interaction with the supplied files, adding the possibility of saving changes and new diagrams.

It is not expected that the reader has previous knowledge about VisSim/Comm, neither about simulation of communication systems. However, a previous contact with the VisSim/Comm documentation may help the reader to achieve an easier and faster interaction with the simulation files and, as a consequence, to speed-up

his learning process. The only previous knowledge that is needed to follow this book refers to notions of communication systems and a solid background in what concerns the mathematics covered in typical Electrical Engineering courses.

Both theoretical and simulation parts of the book can be followed independently, though some simulation results will require comparisons with theoretical ones. It is left to the reader's discretion to go through the entire book sequence or to skip the simulation and go only through the theory and vice-versa. However, for a more complete treatment of each topic, it is recommended that both are followed in the original sequence.

The depth and scope of the book is adequate mainly for undergraduate level, though first-level graduate students can also benefit from the simulation approach adopted. The book can be used as a textbook for a two-semester undergraduate course or for a one-semester graduate and introductory course on digital communications. An important consequence of the simulation appeal is that the computer experiments can be explored as laboratory activities, expanding the course possibilities. Furthermore, the book can be used as a reference for VisSim/Comm users.

In what concern the bibliographical references, I have adopted the approach of providing a huge number of references throughout the text, not only to acknowledge those who have contributed to the field, but also to give the reader the opportunity of complementing his studies or finding details not presented here.

Finally, one might be worried about the caducity of the accompanying software version and of the book itself. However, since we are dealing with fundamentals and well-established concepts, and since upgrades of VisSim/Comm will always be backward-compatible, this work promises to be a life-long textbook that will help the readers to improve their knowledge on digital transmission for a long time. At least, this is what I expect.

Digital Transmission

A Simulation-Aided Introduction with VisSim/Comm

Guimaraes, D.A.

2009, XXIII, 863 p. With CD-ROM., Hardcover

ISBN: 978-3-642-01358-4