Preface

Digital electronic components are present in almost all our private and professional activities:

- Our personal computers, our smartphones, or our tablets are made up of digital components such as microprocessors, memories, interface circuits, and so on.
- Digital components are also present within our cars, our TV sets, or even in our household appliances.
- They are essential components of practically any industrial production line.
- They are also essential components of public transport systems, of secure access control systems, and many others.

We could say that any activity involving:

- The acquisition of data from human interfaces or from different types of sensors
- The storage of data
- The transmission of data
- The processing of data
- The use of data to control human interfaces or to control different types of actuators (e.g., mechanical actuators), can be performed in a safe and fast way by means of Digital Systems.

Thus, nowadays digital systems constitute a basic technical discipline, essential to any engineer. That's the reason why the Engineering School of the Autonomous University of Barcelona (UAB) has designed an introductory course entitled "Digital Systems: From Logic Gates to Processors," available on the Coursera MOOC (Massive Open Online Course) platform. This book includes all the material presented in the above mentioned MOOC.

Digital systems are constituted of electronic circuits made up (mainly) of transistors. A transistor is a very small device, similar to a simple switch. On the other hand, a digital component, like a microprocessor, is a very large circuit able to execute very complex operations. How can we build such a complex system (a microprocessor) using very simple building blocks (the transistors)? The answer to this question is the central topic of a complete course on digital systems.

This introductory course describes the basic methods used to develop digital systems, not only the traditional ones, based on the use of logic gates and flip-flops, but also more advanced techniques that permit to design very large circuits and are based on hardware description languages and simulation and synthesis tools.

At the end of this course the reader:

- Will have some idea of the way a new digital system can be developed, generally starting from a functional specification; in particular, she/he will be able to:
  - Design digital systems of medium complexity
  - Describe digital systems using a high-level hardware description language
  - Understand the operation of computers at their most basic level
- Will know the main problems the development engineer is faced with, during the process of developing a new circuit
- Will understand which design tools are necessary to develop a new circuit

This course addresses (at least) two categories of people: on the one hand, people interested to know what a digital system is and how it can be developed and nothing else, but also people who need some knowledge about digital systems as a previous step toward other technical disciplines, such as computer architecture, robotics, bionics, avionics, and others.

Overview

Chapter 1 gives a general definition of digital systems, presents generic description methods, and gives some information about the way digital systems can be implemented under the form of electronic circuits.

Chapter 2 is devoted to combinational circuits, a particular type of digital circuit (memoryless circuit). Among others, it includes an introduction to Boolean algebra, one of the mathematical tools used to define the behavior of digital circuits.

In Chap. 3, a particular type of circuit, namely, arithmetic circuits, is presented. Arithmetic circuits are present in almost any system so that they deserve some particular presentation. Furthermore, they constitute a first example of reusable blocks. Instead of developing systems from scratch, a common strategy in many technical disciplines is to reuse already developed parts. This modular approach is very common in software engineering and can also be considered in the case of digital circuits. As an example, think of building a multiplier using adders and one-digit multipliers.

Sequential circuits, which are circuits including memory elements, are the topic of Chap. 4. Basic sequential components (flip-flops) and basic building blocks (registers, counters, memories) are defined. Synthesis methods are presented. In particular, the concept of finite state machines (FSM), a mathematical tool used to define the behavior of a sequential circuit, is introduced.

As an example of the application of the synthesis methods described all along in the previous chapters, the design of a complete digital system is presented in Chap. 5. It is a generic system, able to execute a set of algorithms, depending on the contents of a memory block that stores a program. This type of system is called a processor, in this case a very simple one.

The last two chapters are dedicated to more general considerations about design methods and tools (Chap. 6) and about physical implementations (Chap. 7).

All along the course, a standard hardware description language, namely, VHDL, is used to describe circuits. A short introduction to VHDL is included in Appendix A. In order to define algorithms, a more informal and not executable language (pseudocode) is used. It is defined in Appendix B. Appendix C is an introduction to the binary numeration system used to represent numbers.

Tarragona, Spain — Jean-Pierre Deschamps
Bellaterra, Spain — Elena Valderrama
Barcelona, Spain — Lluís Terés

http://www.springer.com/978-3-319-41197-2

Digital Systems
From Logic Gates to Processors
Deschamps, J.-P.; Valderrama, E.; Terés, L.
2017, XV, 241 p. 250 illus., 33 illus. in color., Hardcover
ISBN: 978-3-319-41197-2