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DIGITAL ELECTRONICS
Laboratory

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Foreword

DIGITAL ELECTRONICS - laboratory *is intended to be an invitation for those who would like to start a career in the domain of digital integrated circuits.*

Digital IC technology advances year by year at a rate which is unimaginable for other areas of technology. However the basic knowledge remains the same and lays the foundation for developing a career in the field of digital electronics engineering. After all, every digital system, no matter how complex is, it is built from logic gates and flip-flops...

A pre-request for the laboratory is the **Digital electronics** *course. The course website is:*

`www.dannicula.ro/ed`

DIGITAL ELECTRONICS - laboratory *have two main objectives:*

- *Presenting the properties of the real-life digital signals. Real digital signals are not as "beautiful" and rectangular shaped as the ones seen on course presentations and simulation waveforms. The real waveform of digital signals can be viewed by using an oscilloscope. Both digital and analog oscilloscopes have advantages and disadvantages when it comes to the investigation of digital signals, but the oscilloscope will remain an essential tool in the praxis of an electrical engineer, even in the "age of virtualisation".*

  The author considers that the know-how of using an oscilloscope is part of the elementary and fundamental knowledge base of every electrical engineer practising hardware.

- *Presenting the design methodology of digital systems implemented on Xilinx FGPAs (Field Programmable Gate Array). All digital systems described during laboratory classes are based on schematic description. The design of more complex digital systems is covered in the* **"Hardware Description Languages"** *course which has laboratory and project classes allocated as well.*

The first objective (the know-how of using oscilloscopes) is permanently pursued in all laboratory classes, even in the ones dedicated for studying FPGA based digital system implementation.

The second objective (FPGA implementation methodology) is pursued in laboratory classed from 4 to 7.

- **Lab 1** *presents the 3 instruments used in the laboratory: the DC power supply, the programmable function generator and the oscilloscope. Both methods for voltage and time period measurements using the oscilloscope are presented in detail.*

- **Lab 2** *proposes practising the methodology of measurements with the oscilloscope and studying the behavior of RC circuits. RC circuits are modelling the effects which can be observed at the pin connections of an integrated circuit.*

- **Lab 3** *presents the methods of measuring propagation delays. For illustration, the students will make measurements on inverters implemented in TTL and CMOS technology. As part of this lab, the students will also study the behavior of inverters connected in a loop, for both odd and even number of inverters.*

- **Lab 4** *introduces the methodology of digital system design based on schematic description. The implementation will be done on a Xilinx FPGA device.*
- **Lab 5** *proposes practising the digital system design methodology intended for FPGA based implementation. The students will implement some simple combinatorial circuits. The resulted system will be investigated by connecting the inputs to the available switches on the board while the outputs will be connected to LEDs. Thus, the implemented system can be triggered and the behavior monitored with the oscilloscope or the logic analyser.*
- **Lab 6** *continues on exercising the FPGA specific design methodology studying different type of combinatorial circuits like: decoders, multiplexers, adders.*
- **Lab 7** *proposes performing 2 experiments to strengthen the knowledge about latches and flip-flops. The students will study the difference between the behavior of the latch and the D flip-flop.*

The necessary source files needed for the laboratory classes can be found at the following website:

`www.dannicula.ro/books/edEngLab`

To ensure an efficient assimilation of the knowledge of these laboratory, the author recommends the following work methodology:

- *The students should read the laboratory description in advance, in order to refresh the knowledge acquired during the courses. They also should make a plan of the work-flow.*
- *During the laboratory classes, the students must have the text of the current laboratory and a notebook. They will note the results of the experiments, the answers to different questions that can be found in the text as well as the answers for the questions addressed by the professor.*
- *Before the actual laboratory work starts, the professor will verify if the students have the required theoretical knowledge for the the current laboratory. These tests will provide an assessment of 20% of the final grade. If it is considered that the student does not have the necessary knowledge for the lab, because he does not read the text in advance, the student will be denied the right to continue laboratory work.*
- *During laboratory, the students will operate in groups, on a set of laboratory equipments. The professor will provide students with the necessary support and will respond to their questions related to the laboratory work-flow. The activity of the students during laboratory will be evaluated during the semester. This evaluation will provide an assessment of 60% of the final grade. For a correct evaluation, the professor will take into account the student's practical work, the spirit of collegiality, the notes taken in the notebook and the student's personal contributions.*
- *At the end of the semester, students will hold a laboratory assessment. Issues covered in the assessment will be strictly related to the laboratory work done and will represent 20% of the final grade. On this occasion, the professor will make an overall assessment and each student will be given a grade.*

The author appreciates the involvement of the following students in the development of these laboratory classes:

- *Mădalina TURIAC*
- *Nicuşor COJOCARU*
- *Gabriel CARAGEA*

The current book is a translation from Romanian of the book **ELECTRONICĂ DIGITALĂ - Laborator***, Editura Universităţii Transilvania din Braşov, 2009, website:*

`www.dannicula.ro/books/edLab`

Kind appreciation to

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for English translation of the text.

The author appreciates any comments and suggestions on this guidebook made by email to:

`dan.nicula@unitbv.ro`

Braşov, January 2014. **Dan NICULA**

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