Preface

This book introduces you to the **design of logic circuits**. In these times of the scientific journal it has become customary for a scientific book, in the main, to contain well-established knowledge while new findings are presented in scientific journals, preferably ones peer reviewed. As J.R.R. Tolkien says of his Hobbits in the prologue to 'The Fellowship of the Ring', '... they liked to have books filled with things that they already knew, set out fair and square with no contradictions'. But this is not a Hobbitian book: While I certainly have tried to set things out fairly and squarely and hope to have avoided contradictions, major parts of this book contain new findings. These, when put together and presented in context, draw a totally new picture of sequential circuits. As the whole is more than just the sum of its parts, I thought it advisable to give a picture as complete as possible, thus the book form, and not to split the material into small parts adequate for journals, but lacking in meaning if not seen in context.

The subject matter is divided into three divisions, the first covering circuits that have no memorising ability, the **combinational circuits**, the second presents pure memory circuits, the **latches**, the third investigates circuits which have a memorising ability to various degrees, the **sequential circuits**. The presentation is not theoretical, in that most proofs have been omitted, hopefully making the text more readable. But there is still enough algebraic content to warrant using paper and pencil parallel to reading the book.

Part I, on **Combinational Circuits**, draws completely upon the first three divisions of Vingron (2004); their approximately 260 pages have not only been excerpted to the present 95, but a number of improvements have been put in place (Sects. 1.1–1.3, and 2.2, Chaps. 5, 6, and 8). Especially Chap. 8, on the composition of combinational circuits, points to a new and important design technique. With a heavy heart I have refrained from all proofs in connection with normal forms (Chap. 4) and have omitted chapters on *nand* and *nor* design techniques, and on *hazards*. Combinational circuits are quite easily recognised as being describable by the laws of logic. In a rather roundabout way this insight was first achieved by analysing circuits built of electric relays, but is, of course, independent of the technology by which a circuit is realised.

Part II is on **Latches**, these being the elementary form of sequential circuits, and allowing us to study memorisation in its most basic form. Memorisation is conventionally taken to be a time-dependent phenomenon, a notion that has always stood in the way of describing latches (and subsequently sequential circuits) by the the laws of logic (as was so successfully done for combinational circuits). The major achievement, presented in Chap. 9, is to find a time-*independent* description of memory making it possible to use logic in its conventional form (not, temporal logic) in working with latches. Despite a superfluous similarity with the division on latches of Vingron (2004), the present division on latches has been completely reworked and rewritten (especially Chaps. 9 and 10) putting the theory of latches on a new footing.

Part III is on ***asynchronous*** **sequential circuits**. Their theory was initiated by Huffman (1954) landmark paper '*The Synthesis of Sequential Switching Circuits*'. In this wonderfully readable paper (no maths!) he actually didn't present a theory—he put forth verbally expressed procedures saying how to develop asynchronous circuits. His presentation and arguments were so persuasive that all subsequent theory (it came to be known as automata theory) seemed to be focussed on providing a mathematical background and justification. The quantized time-dependent mathematical models that automata theory developed led to the introduction of **synchronous** sequential circuits. They are usually explained as being clock driven meaning that all switching activity takes place during brief and periodically recurring time intervals. Asynchronous circuits (Huffman's original sequential circuits) are not clocked. They employ continuously present signals, and the outputs can change whenever an input changes. Automata theory had practically no success in advancing the theory of asynchronous circuits.

Part III breaks with the standard synthesis procedure for asynchronous circuits as initiated by Huffman. For one thing, the three representations used in specifying an asynchronous circuit—the events graph, the word-recognition tree and the flow table (a slightly advanced version of Huffman's famous flow table)—are time-independent idealisations. This allows us to build on the theory of latches, as put forth in Part II, and to freely use logic in the same way as for combinational circuits and for latches. The basic problem confronting the standard synthesis procedure is finding a binary encoding for the flow table. Chapter 15 presents an algorithmic solution for the encoding problem. Another hitherto unsolved problem is that of verifying a sequential design. A solution to this problem is given in Chap. 18. Many of the methods and procedures of Part III are greatly improved and expanded versions found in Vingron (2004). I have refrained from a discussion of standard theory as there are excellent books on the subject (my favourites being Krieger (1969), and Dietmeyer (1971)).

Sections and chapters containing relevantly new material are marked by an asterisk (∗). Much of the information conveyed is contained in the figures which is why I have designed and drawn them very carefully. In general I would suggest not to just fly over them. The index contains not only page numbers, rather it also refers to figures (as in: *see* Fig. 13.5) or equations (as in: *see* Eq. (13.5)). You will find the chapter number (e.g., Chap. 13) in the page headers. I always appreciate comments, and invite you to write me at ***vingron@kabsi.at***.

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