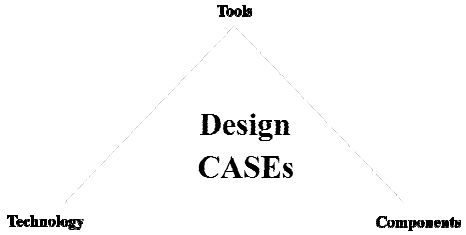

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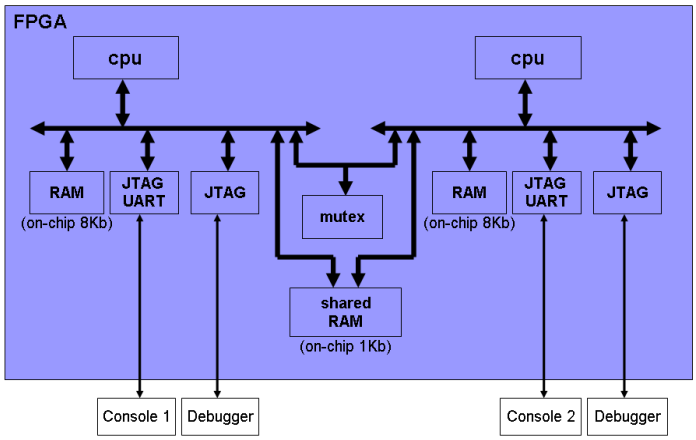
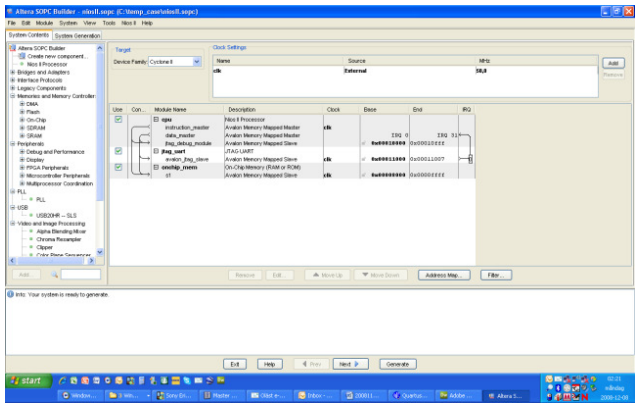
HW/SW Embedded System Design with FPGA Technology, 2009

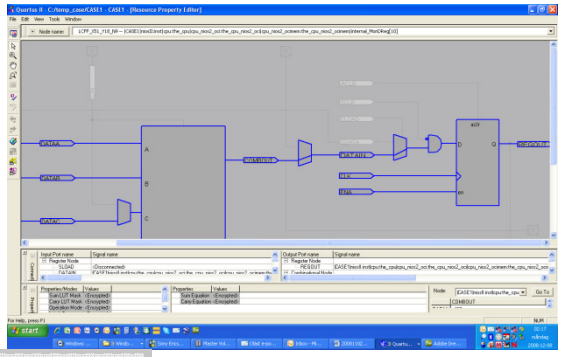
- Engineering approach -





Highlights:

- Flexible hardware and software
- HW/SW Component Design
- SW Device driver
- Multiprocessor System
- Hardware based Real-time Kernel
- Documentation
- Learn by doing
- Configurable Computing



Use complex components (CPU, busses etc) and simulation, design and debugging SW/HW PC tools for practical training.

Lennart Lindh and Tommy Klevin

HW/SW Embedded System Design
with FPGA Technology

Version 1, Swedish, 2005 programmerbara kretsar – Utveckling av inbyggda system, ISBN 91-44-03713-9, www.studentlitteratur.se

Version 2, 2008 HW/SW Embedded System Design with FPGA Technology, www.agstu.com.

- Translated version 1 to English and new practical training.

Version 3, 2009 HW/SW Embedded System Design with FPGA Technology, ISBN 978-91-977667-0-8, www.agstu.com.

- Updated the methodology
- Updated bus sections and component design
- Updated Sierra CASE and new RTK CASEs
- Updated device driver code
- Add new CASE, verifying the Timer CASE with ModelSim
- Mention Reconfigurable Computing, this will be more described in the next version.

Dragverksg 138, S-724 74 Västerås, Sweden. Mail: publisher@agstu.com. www.agstu.com

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Preface

The aim of the book is to prepare you for real SW/HW embedded system design with FPGA technology, by walking step by step through entire designs together with adequate theory.

The software tools used in this book are professional and free to download. The educational FPGA board costs around 265 dollars, you can by a simpler board for 125 (DE1) or 79 dollar (DE0), at www.terasic.com . We hope you will enjoy our guided journey in this book.

The FPGA technology has a huge impact on today's development process, and also on how we conduct science and engineering. One of the limitations today is the insufficient knowledge of how to fully exploit FPGA technology. The design space for FPGA devices is large and fascinating with efficiencies that vary by orders of magnitude. A good engineer and researcher must know the fundamental tradeoffs to be able to re-evaluate solutions as the underlying technology changes, like FPGA technology. We will certainly see a dramatic change when FPGA technology will be further explored in the development and research process in the near future.

Many different areas of knowledge are merged together in the design process of embedded system on chip solutions. Subsequently, those who design on a high level of abstraction must have a very broad competence.

Organization of the book

The area described in the book spans over a wide range of knowledge, stretching from technology, operating systems, computer architecture, methods and different tools.

The book is divided into background, introduction, FPGA technology, tools and components and CASE (practical training). The theory is sometimes integrated into the CASEs, to get as short a distance as possible between practice and theory. The purpose of the CASE is "learn by doing".

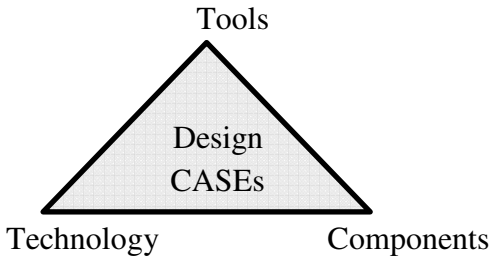

Figure 1: The three key areas and the implementation in the CASEs

The book concentrates on technologies, tools and reusable components for FPGA. Those three key objects are then analyzed and later used in an engineering way to guide you through theory and practical CASE studies.

Technology is the physical FPGA chip, consisting of the fundamental programmable small building blocks.

Components are reusable SW/HW components, which can be assembled like Lego bricks (usually called IP components, Intellectual Property).

Tools are the tools that make the construction work easier.

CASEs are examples of real designs.

Acknowledgement

We thank the following persons for small or larger contributions, comments and/or inspiration (and our apologies to those not mentioned here):

Graham McKenzie, Birger Egnér, Johan Furunäs, Susanna Nordström, Andreas Löfgren, Erik Käll, Jens Lindh, Kerstin Åberg, Johan Stärner, Katarina Myrehed, Farshid Atachi, Lars Johansson, Anders Karlström, Amir Sejdinovic, Tobias Skoglund, Björn Thor, Mathias Vall, Peter Westling, Johan Bard, Lukas Knapik, Trond Rogne Øyre, David Johansson, Jakob Lindgren, Johan Palm, Sigurd_Bårdsen, Anders Nesheim Vinje, Mats Karlsson, Gustaf Naeser, Martin Næsse, and last but not least all the hundreds of students we have had. The book could not have been made without all these inspiring people!

The book has its own web page: see www.agstu.com, there can you perhaps find extra material.

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Lennart Lindh works at the university and in the industry. For many years he has been engaged in research and development of products with FPGA technology. His most well-known result is real-time kernels for single- and multiprocessor systems in hardware. He has written several books about FPGA, HW/SW systems, VHDL and real-time systems.

Tommy Klevin is employed in the industry at present. He has previously done academic work as well and has, in cooperation with Lennart Lindh and a team of researchers, worked a lot with issues concerning performance in real-time systems, and a large part of this focused on moving parts of operating systems from software to hardware (ASIC/FPGA). Everything from a small real-time OS up to Linux has been part of the research work.

HW/SW Embedded System Design with FPGA Technology

The motivation for reading this book is the increase of implementations of FPGA (Field Programmable Application Gate Arrays) devices in embedded products. The aim of the book is to prepare you for real embedded FPGA system projects by walking step by step through an entire design of an embedded system together with adequate theory.

The FPGA technology has a huge impact on the development process, and also on how we conduct science and engineering. One of the limitations today is the insufficient knowledge of how to fully exploit the FPGA technology. The design space for FPGA devices is large and fascinating with efficiencies that vary by orders of magnitude. Further, the limitations of our technology are changing, so the "right answers" of the past will almost certainly become outdated. A good engineer and researcher must know the fundamental tradeoffs to be able to re-evaluate solutions as the underlying technology changes, like FPGA technology. We will certainly see a change in the development process and research topics in the near future in the area of embedded systems.

Many questions arise, such as: how and where do we draw the boundary between hardware and software? How do we organize a component design paradigm with enormous power of parallel processing? What is most important to optimize when the price is close to zero for one gate?

The book concentrates on **technologies, tools** and **reusable components** for FPGA. Those three key objects are then analyzed and later used in an engineering way to guide you through theory and practical CASE studies.

FPGA technology is relatively new and very important in many applications, in terms of development cost, performance, power consumption etc. The well-known friend to FPGA technology is “Moore’s law”, which still predicts that the number of gates will increase and the cost decrease.

Tools are important for optimizing the development process; archiving short development time, cost optimal solutions, minimizing the risks of bugs etc.

Reusable components have the purpose to decrease the risks, shorten development time etc.

The book is divided into background, introduction and CASE (practical training). The theory is sometimes integrated in the CASEs, to get a short distance between practice and theory. The CASE purpose is to “learn by doing”.

The book can be order on www.agstu.com

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