Bringing the Idea of Mars to Life

An application report on HW/SW-codesign for a medical product

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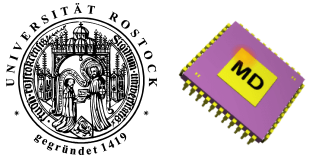


Purpose

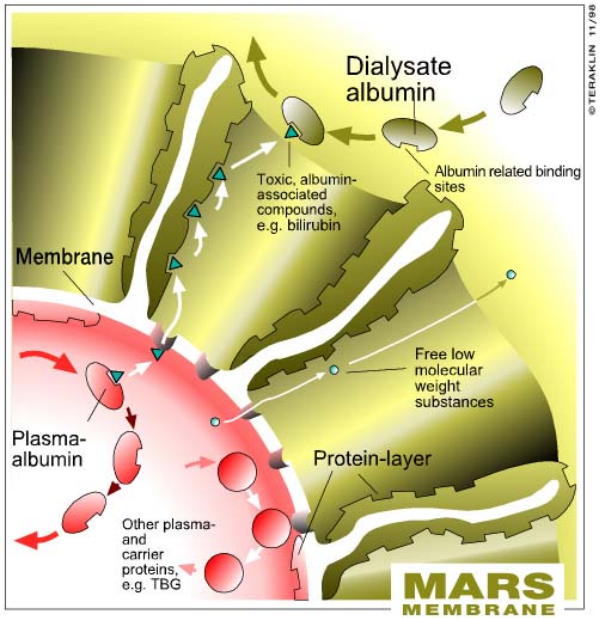
- development process of the electronic components of a medical instrument
- special requests by the area of application
- hardware/software co-design for optimizing the development process
- utilization of Smartmodel based simulation
- project management

Outline

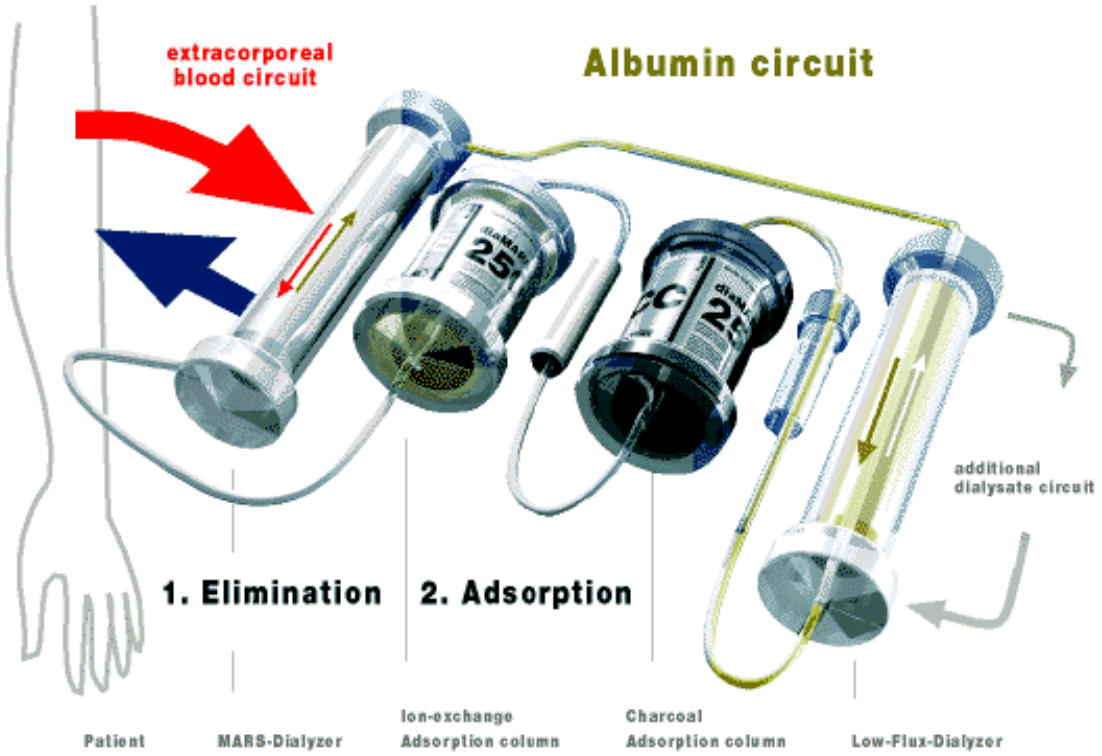
- Purpose
- Medical background
- The final product
- Special requirements on medical equipment
- Target design
- MARS Mainboard System Chip architecture
- Design process
- Co-design
- Project management
- Conclusion

Medical background

- Molecular Adsorbents Recirculation System
- removal of protein bound and water soluble toxins



ELIMINATION OF TOXINS



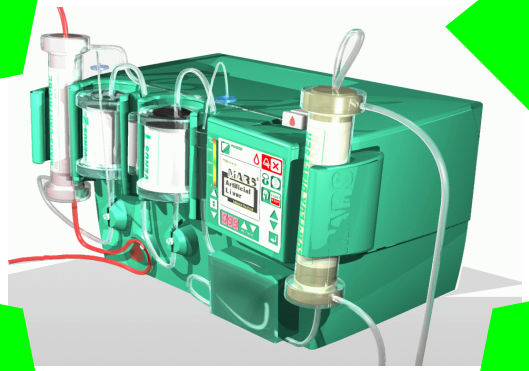
The final product

- the artificial liver is the first albumin dialysis system
- a medical device for the performance of the liver support therapy MARS
- used the existing dialysis equipment
- designed in cooperation with dialysis specialists and nurses
- Classification protection Class I Type B

Special requirements on medical equipment

reliability

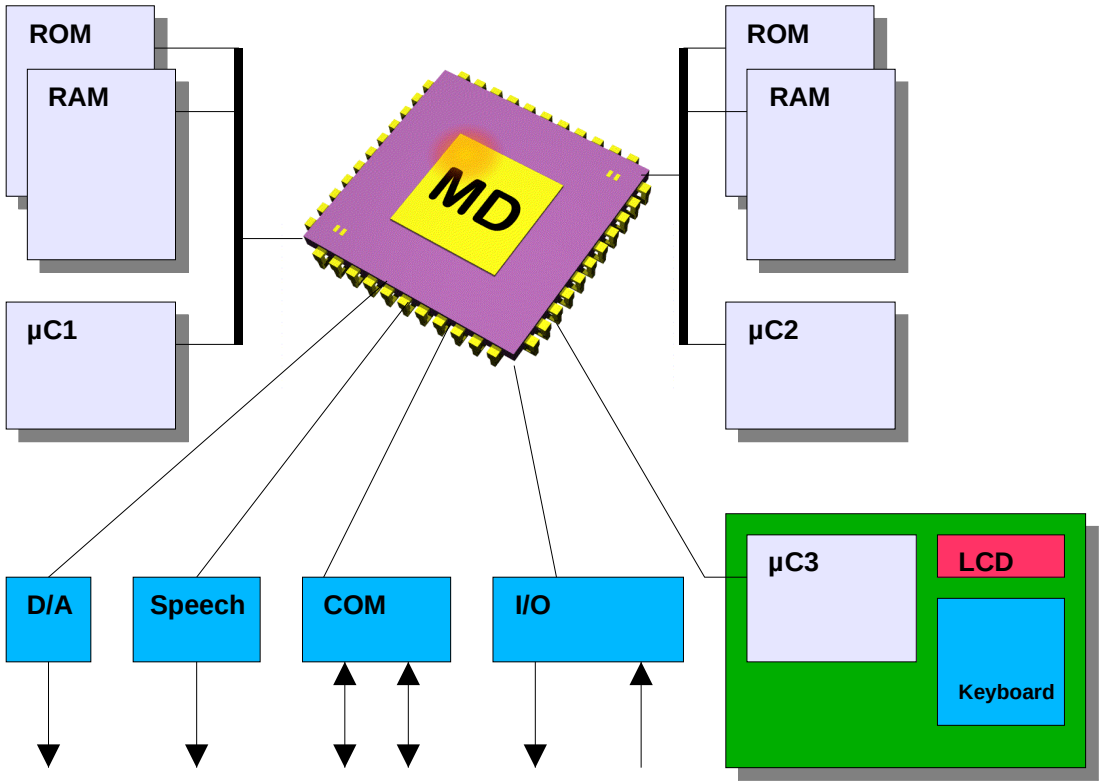
electro-magnetic radiation



electro-magnetic tolerance

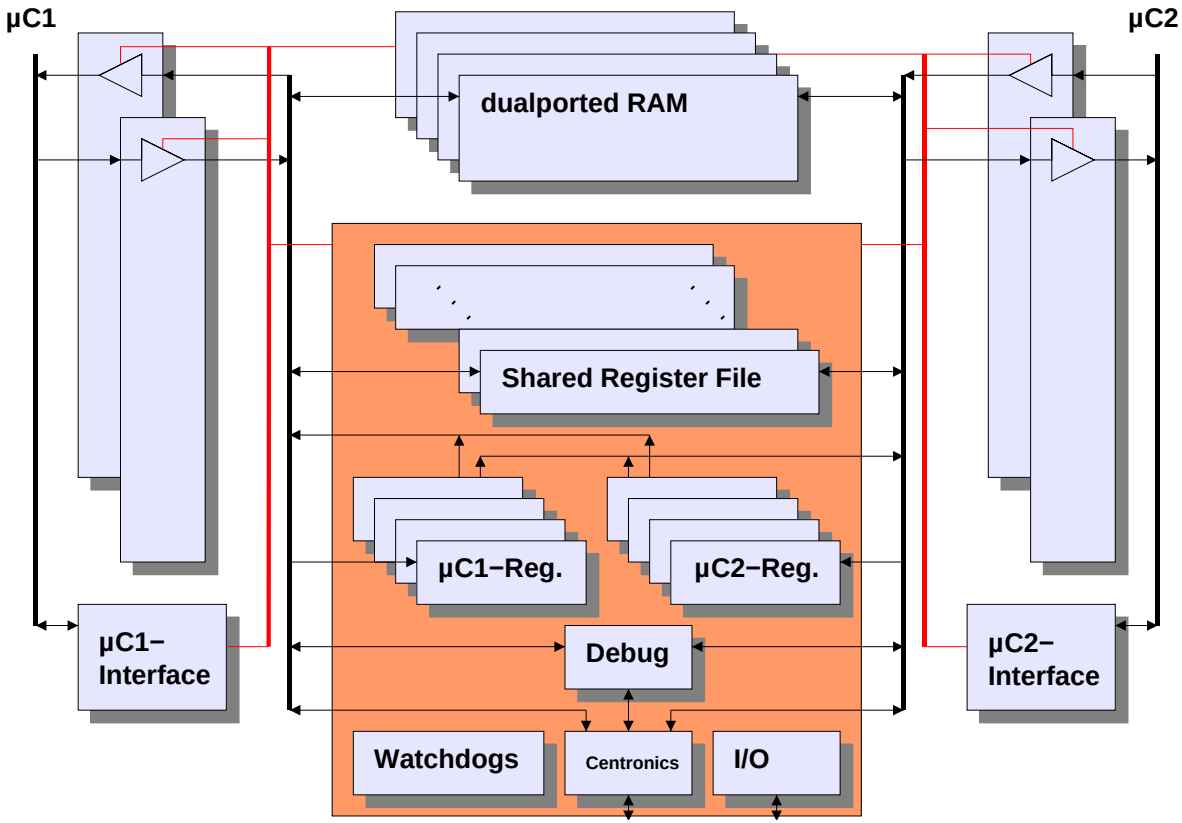
self-monitoring

Target design



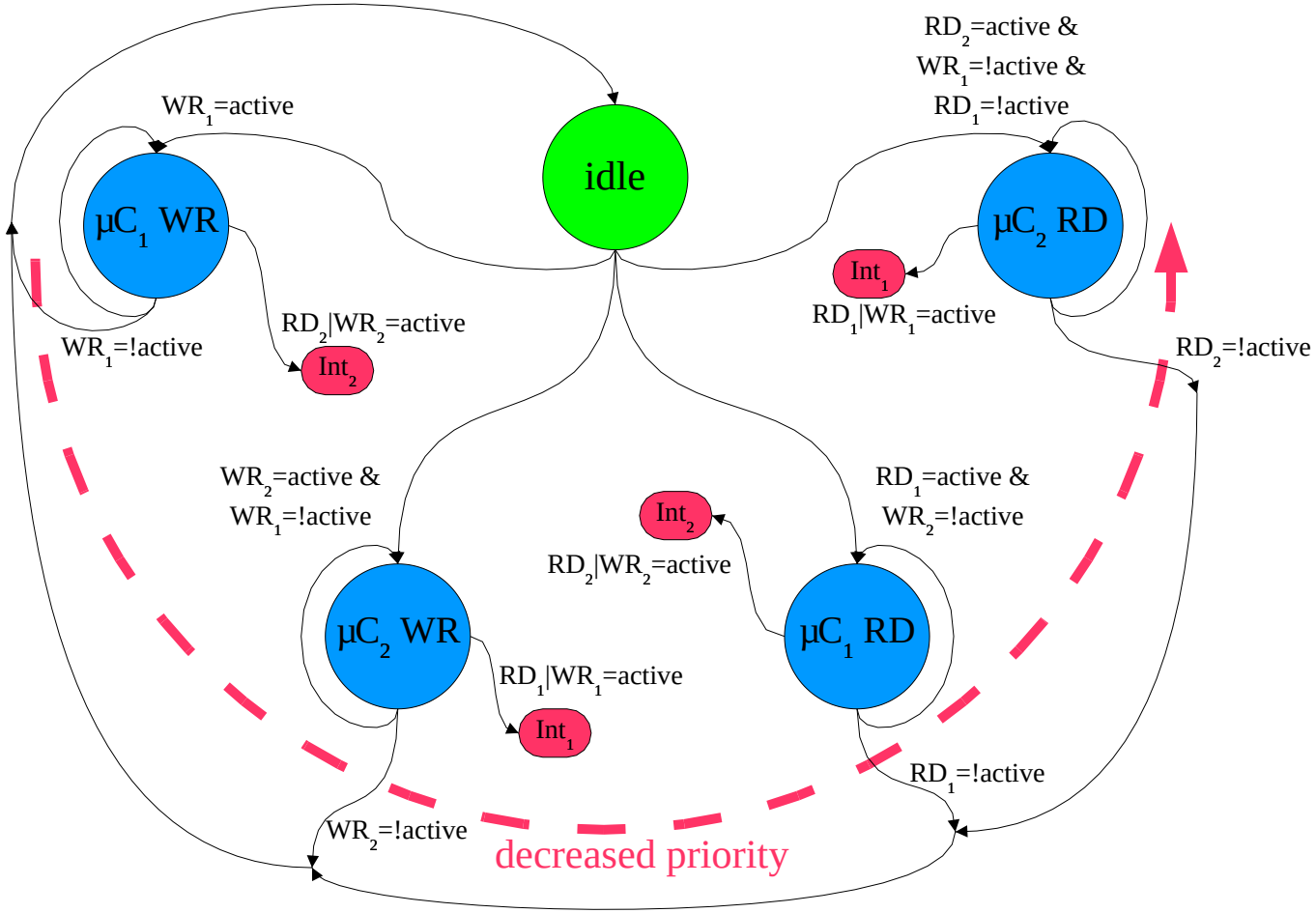
- i8051 derivate based redundant μC-system
- fully decoupled systems for increased reliability
- access check for shared resources
- self monitoring ability

MARS Mainboard System Chip (m2sc) architecture

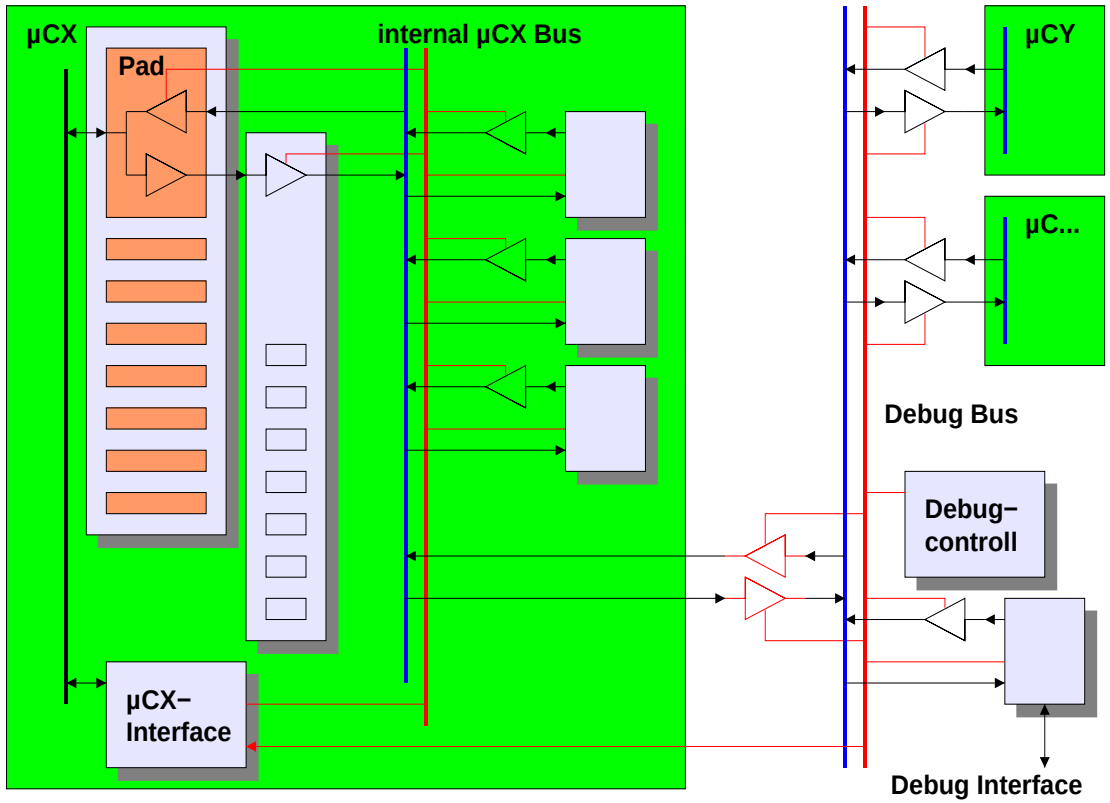


- FPGA implementation
- scalable architecture, currently only 2 μC implement the redundant system
- memory mapped I/O architecture
- communication through shared memory segment

Access and resource control



Bus structures



- scalable count of participating μC
- limited gate resources due to FPGA implementation
- utilization of overhead on available tristate elements
- busses divided into an external and an internal segment
- additional debug interface bus

Design process - organization

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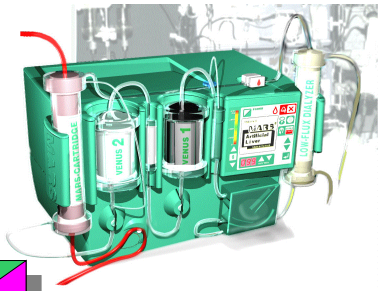
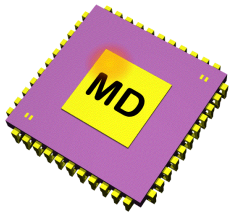
- MARS−technology
- system design
- software development
- certification
- fabrication & marketing



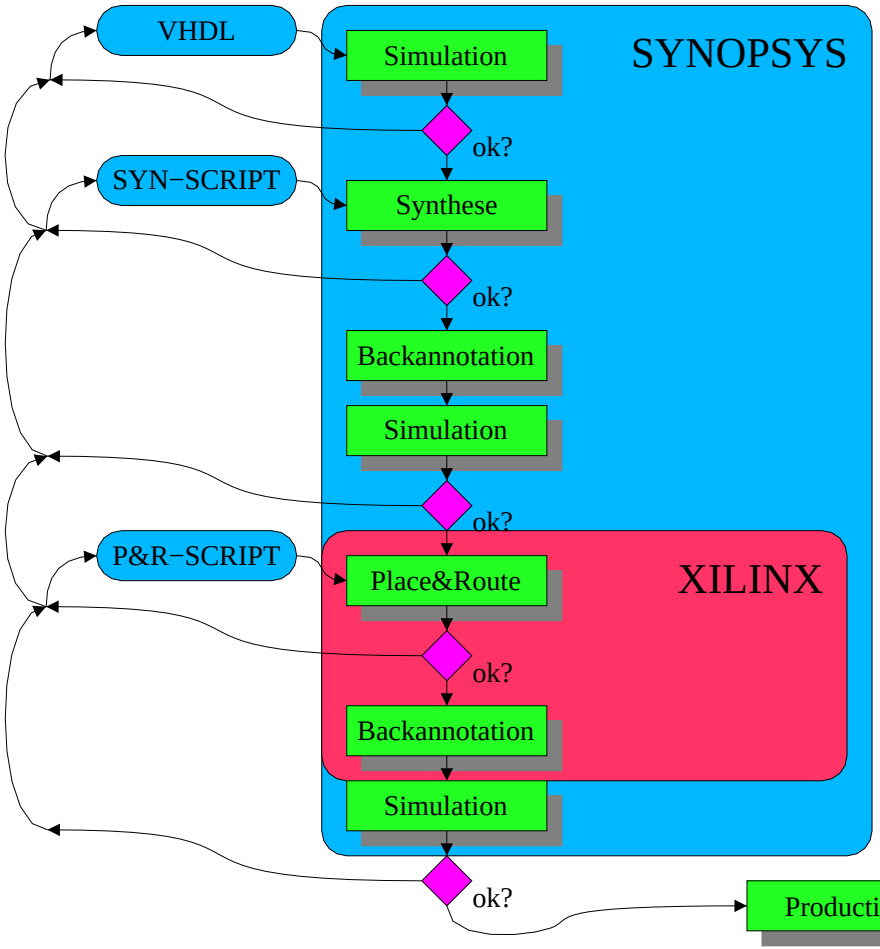
- system design consulting
- m2sc development
- verification

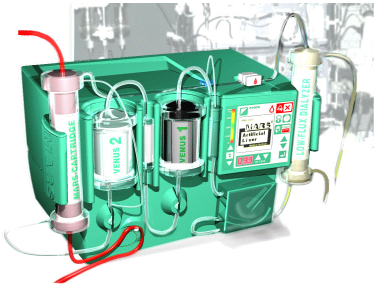


MARS

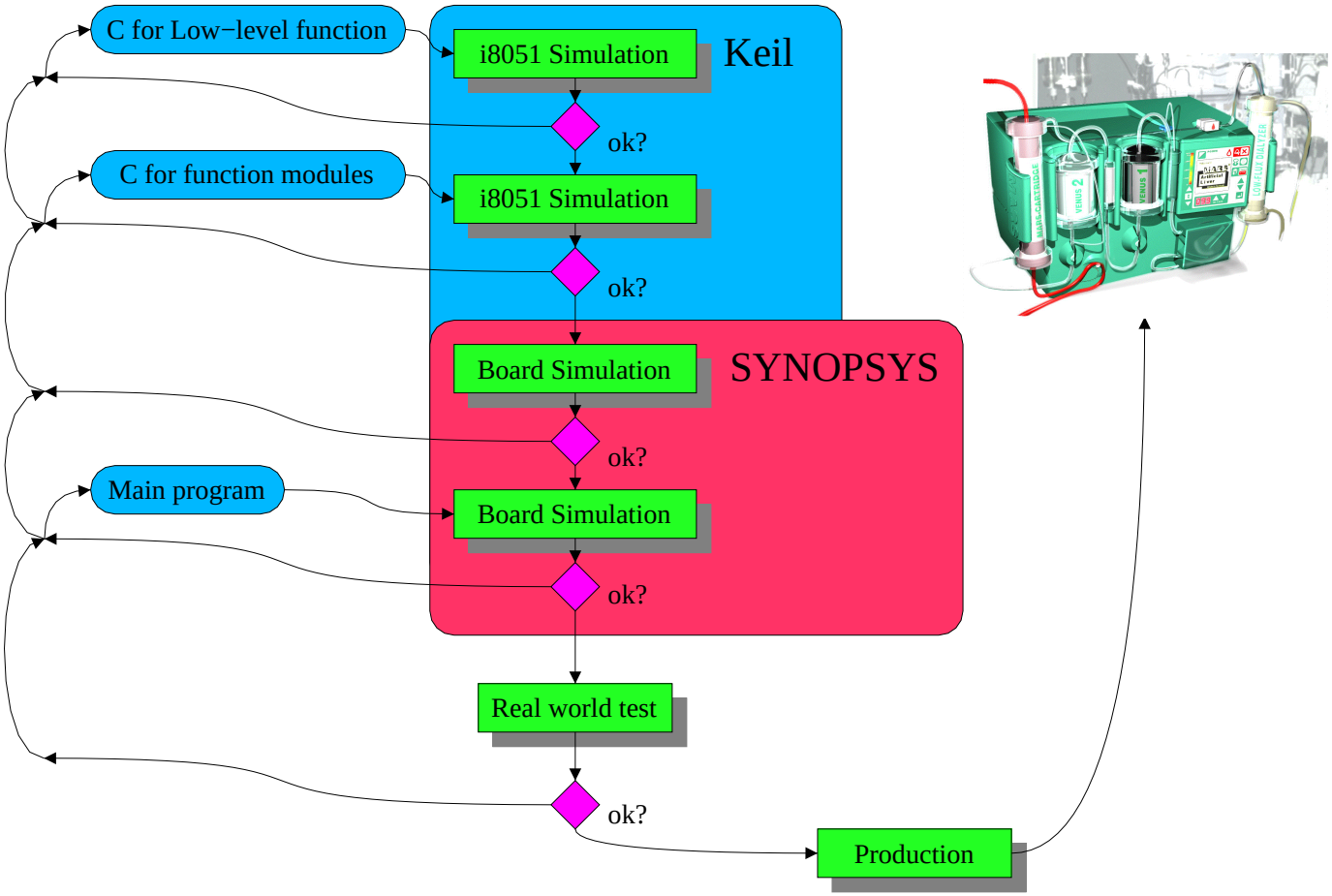
Molecular Adsorbent Recycling System

Hardware design flow

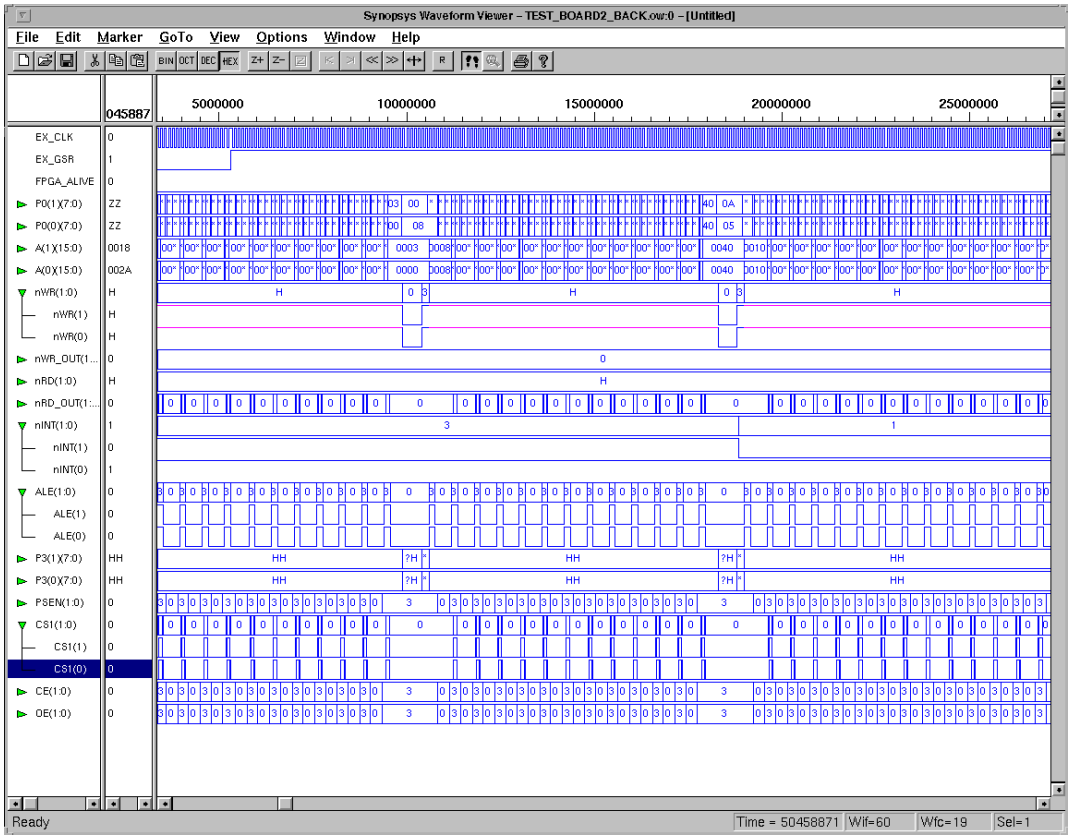




Software design flow

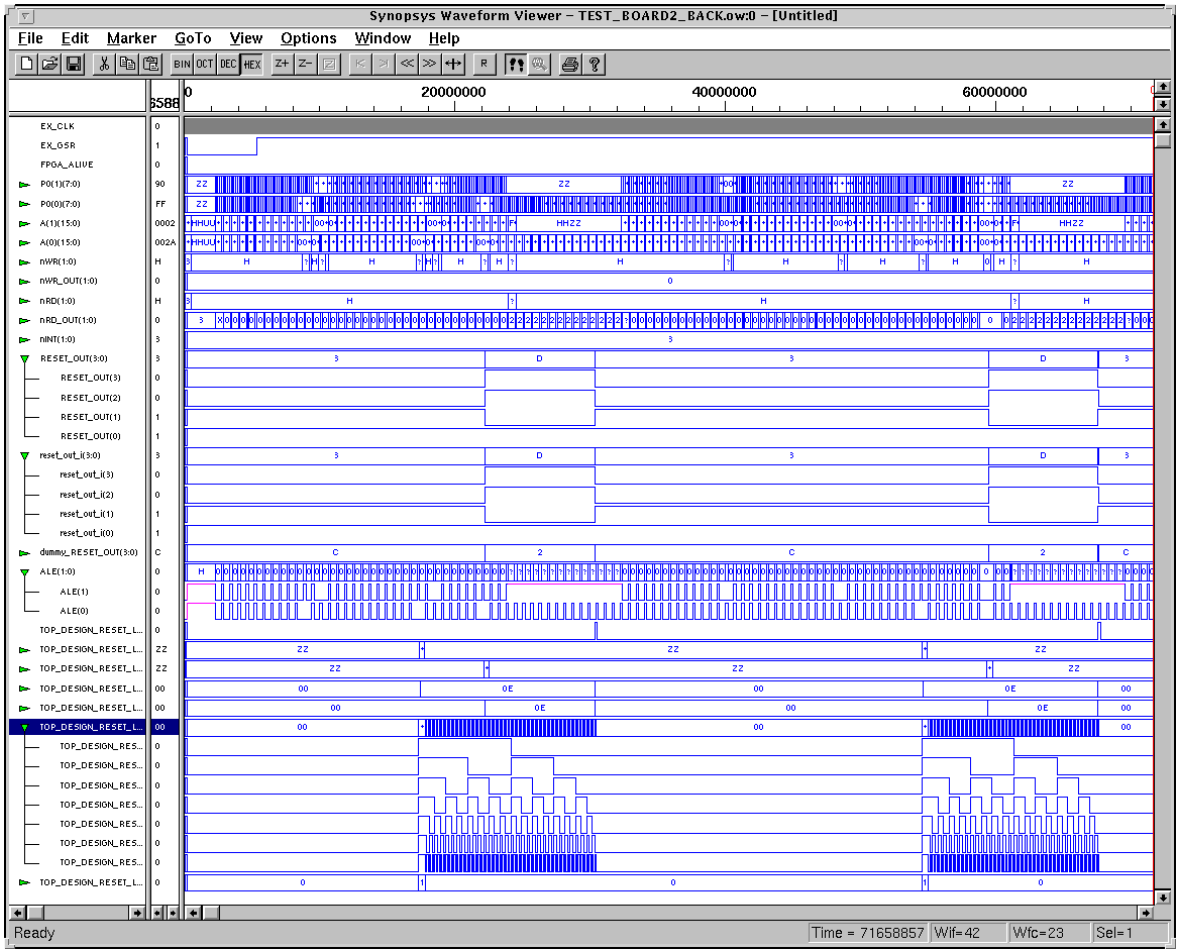


Co-design: example interrupt on resource access conflict



- verification of interrupt generation
- difficult to test without co-simulation
- validation of the software answer on the interrupt possible

Co-design: discovery of the multiple reset bug



- problem: internal reset fails on the real device
- undetected in the pure VHDL simulation
- co-simulation reveals the bug after the first reset
- bug: incomplete VHDL description resulting in a circuit which has been removed by XILINX P&R tools

Project management

VHDL-project

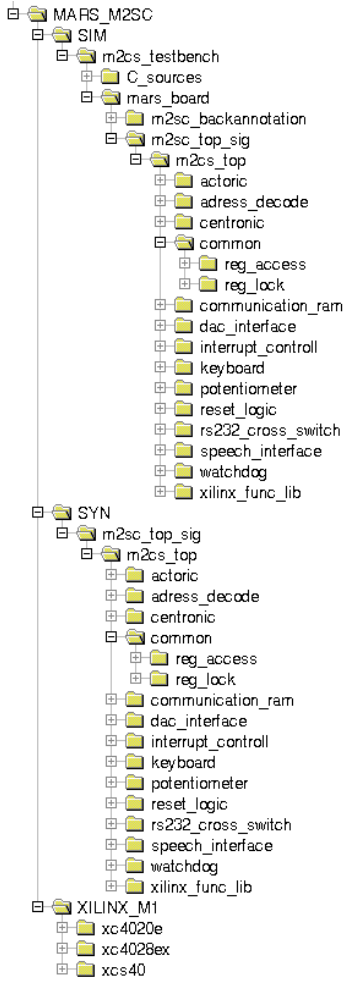
- make based preparation
- handmade makefiles
- separate tree for simulation and synthesis
- rcs project management

C-project

- wintel pc hosted
- ide from Keil with project management

Co-design

- make based preparation
- sparc/solaris hosted
- co-simulation with Synopsys Smartmodel



Conclusion

- presented the design process of the medical device MARS
- a short introduction of the special requirements when developing medical equipment
- verification by co-simulation reduced development time
- design bug recovery time reduced as well
- reduction of computing time by utilization of Cyclone for large co-simulation
- future use of automatic makefile generation for preparation of synthesis and simulation (like vmkr)
- integration of a project management functionality into the synopsys tools would be useful