University of South Australia

School of Electrical and Information Engineering

VLSI Design G

Strategies for problem solving and critical thinking in VLSI Design

This handout is an outcome of the student-centred learning workshop held in week 3. It contains summary of your group work on problem solving and critical thinking. UniSA learning adviser Monica Behrend collated your responses and added some relevant notes from the textbooks. I have compiled the final document in the current form.

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1. Introduction

This handout has two main parts: (1) problem solving strategies and (2) critical thinking strategies. Both of these parts have been compiled mainly from your group work, brainstorming and presentation during the student-centred learning workshop in week 3 of this study period. You will be familiar with many of the things in this handout. I therefore hope that you will find this resource useful for problem solving and critical thinking in the VLSI Design course as well as in other courses and in real-world engineering problems.

2. Problem solving strategies for VLSI Design

These lists of useful strategies were compiled based on your experiences, and your textbook (Weste & Harris 2005) and a reference book (Pucknell & Eshraghian 1988).

2.1 Understanding the problem

- Read the problem (even 3-5 times!) and understand the problem using background knowledge
- Ask questions about any confusions
- Refer to and review relevant information in your textbook or lecture notes
- Identify the steps needed when normally solving this type of problem e.g. a logic design normally starts by defining the top-level interface and block diagram (Weste & Harris 2005, p. 46)
- Know the rules well and the reasons for these rules (for example Weste & Harris 2005, p. 126-9)
- Focus on essential features
- Identify what are the required inputs, outputs, data, ..
- What parameters need to be varied? What are the implementation steps
- Synthesise the CKT
- Link the relations
- Work out how the software works and why using this software
- Know the basic knowledge about MOS
- Make notes for example (Weste & Harris 2005, p. 11) summarise information about CMOS inverters on a table.

2.2 Devising a plan

- Draw a layout, draw stick diagrams
- Consider the interrelated tasks for architecture, microarchitecture, logic, circuit and physical design (Weste & Harris 2005, p. 36)
- Aim to keep the model simple (Weste & Harris 2005, p. 106)
- Beware of CMOS process options and directions
- Divide the problem into sub-problems and systems into sub-systems
- Identify resources needed to solve the problem
- Consider if the plan is feasible
- Have a positive attitude
- Discuss with experts and peers

(Pucknell & Eshraghian 1988, p. 268-9)

- Never bend the rules
- Try to put the requirements into words
- Aim for generality and regularity
- Set out rules of system timing
- Do not take liberties with the design rules
- Remember IC designers should expect their systems to function first time around

2.3 Carrying out the plan

- If you get stuck, check that you are looking at the correct part of the circuit
- Do not take liberties with the design rules
- Work out how WinSpice works (load file, run and plot)
- Follow a step-by-step procedure
- Change parameters to get difference results and analyse the changes
- Compare results with theory and be able to explain why and how they are different from theory
- Implement the results obtained in other problems
- Review whether the required objectives are achieved
- Do we have enough time to carry out the plan?

2.4 Looking back

- How are you going to test your designs?
  - ‘Testing, testing, testing’ (Weste & Harris 2005, p. 567)
    - Test intended function (functionality tests, logic verifications)
    - Test first batch to help debug any discrepancies
    - Verify components function correctly- manufacturing tests
- What tools and techniques do you have to test your designs?
- Did you achieve your goals in the project?
- If you didn’t achieve all the goals reflect on what and why?
- What learning did you accomplish by doing the project?
- What would you do differently next time to increase chances of success?
- Refine your strategies for future problems/ projects?

3. Critical thinking strategies for VLSI Design

The first couple of lists (3.1 and 3.2) were compiled based on your experiences.

3.1 What is critical thinking?

- Analysing parts of a process in details
- Deciding how something works
- Asking the question ‘Why?’
- Considering advantages and disadvantages; strengths and weaknesses
- Seeing different perspectives
- Seeking alternative solutions

3.2 Examples of critical questions

Some examples of critical questions to ask in VLSI Design (most relating to the CMOS inverter from Project 1) are:

- How can I reduce the rise time?
- Why do we keep increasing with the p-transistor?
- Is there any other way to give good noise simulations?
- What causes current spike when capacitors are discharging?
- Why doesn't it match spike when charging?
- What are other design aspects of CMOS inverter?
- Why is rise time greater than the fall time?
- Why was there ASCII plot? What does it mean?
- What is the application of the CMOS inverter?

3.3 Addition to your list

In relation to the CMOS inverter project you may think about the following additional issues/questions to assist you in applying critical thinking in further VLSI Design projects:

- Why are the rise and fall time of CMOS inverter not equal?
- How can the rise and fall time be made equal?
- What are the alternatives for doing so? (You may list these alternatives with possible values of transistor widths and lengths).
- Which alternative is preferable? Why?
- What impact will this alternative have on the performance of the circuit?
- Is it important to have equal rise and fall times? If so when, i.e. in which type of circuit)?
- What would be your choice in most circuit design situations: achieve equal output rise and fall times or using minimum geometry transistors throughout the design? Why?

3.4 Ask questions

Remember to ask questions at the four different levels of understanding (refer to handout)

1. **Literal**
   - What? Where? When? What with? …

2. **Lateral**
   - How? What for? What response? What then? What else is going on? …

3. **Critical**
   - Is this good? Why? Could it be better? How useful is it? Did it work? …

4. **Speculative**
   - Could it happen differently? What's needed? What next? What if …? …

References

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Polya, G 1957, *How to solve it*, 2nd edition, Princeton University Press, Princeton.

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Weste, NHE & Harris, D 2005, *CMOS VLSI Design: a circuits and systems perspective,* Addison Wesley, Boston.