Exam solutions (DAT093)

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What follows are brief suggested answers/solutions. Other solutions than those listed here may be acceptable.

1. *The lecture on power dissipation brought up several ways to manage and/or reduce dissipation at different points in the design process. Briefly describe up to four of these. You'll get two points per separate and well-enough described approach.*

   The lecture included the following perspectives on power:

   - Technology platform choice
   - Logic design decisions
   - Clock gating
   - Supply voltage selection
   - Processor architecture
   - Software design
   - System architecture
   - Project planning

   Refer to the slide set for suggestions on approaches according to each perspective.

2. (a) *What is the meaning of the term "Platform design"?*

   Planning from the outset to use a certain design in a set of different products with different specifications. The "platform" may include several hardware and/or software components, all of which may not be included in any given product.

   (b) *How might a designer reduce the defect yield loss for her semiconductor design? What about performance yield loss?*

   Redundancy, error-correcting codes (ECC), and built-in self test (BIST) may improve defect yield loss; circuit adaptivity may help with performance yield loss. Future remedies may include more regular designs, more redundancy, and more radical reconfiguration if an entire subdesign is unusable due to an error.

3. (a) *Compare and contrast hard and soft deadlines in a real-time computing system.*

   Failure to meet a hard deadline causes system failure; missing a soft deadline merely degrades the user-percieved quality.

   (b) *How might you verify the real-time propertes of a computing system?*

For example through ad-hoc testing, exhaustive testing, or formal analysis of system properties. The first alternative rarely gives the necessary confidence; the second may be very expensive.

(c) *How does pipelining improve performance of a microprocessor?*

The processor makes progress on several instructions simultaneously, by fetching and decoding subsequent instructions while executing and saving results of the current ones. Since each of the partial instructions can be completed in less time than would be needed for a full instruction, the overall performance can be improved.

(d) *What limits the number of cores in a multicore processor?*

Power is one good answer: overall dissipation from a single package is more-or-less fixed (disregarding heroic efforts of liquid cooling and other exotica), so a higher core count means each core must dissipate less. Also, software parallelism is needed to keep many cores busy, and most applications have limited amounts of parallelism.

4. *You are asked to design the digital parts of an embedded electronic system. One of the most important decisions is what technology platform to use. Give two possible reasons to choose each of the following platform alternatives.*

Here are some:

(a) *Software on off-the-shelf processor*

Low NRE cost and fast edit-compile-test cycle enable quick and cheap development

(b) *Hardware-description language implemented on an ASIC*

The best performance and power dissipation, but the large NRE costs typically require long manufacturing runs

(c) *Hardware-description language implemented on an FPGA*

NRE costs similar to case 4a above, at a higher performance and/or lower power

(d) *Software on custom-designed processor implemented as an ASIC*

Some particular computations not well-supported by off-the-shelf processors, combined with the programmability for quick development of applications once the processor exists

5. *Briefly discuss the following aspects of PCB design.*

(a) *Surface-mounted vs through-hole-mounted components*

Surface-mounted components may be much smaller and lighter, and do not impede signal trace routing on inner PCB layers. Through-hole mounting is mostly used for physical anchoring of large, heavy, high-power, or otherwise mechanically-stressed components.

(b) *Choice of substrate material and number of layers*

The default substrate material is a glass-reinforced epoxy resin known as FR4. Other materials may be chosen for physical flexibility, for heat transfer, or for better high-frequency properties. A larger number of layers may improve component packing density by offering more signal routing opportunities, but cost is affected.

(c) *Signal reflections*

A signal travelling down a PCB trace may be described by a one-dimensional PDE known as the Telegrapher's Equation. Wherever the characteristic impedance of the PCB trace changes, the solution to the PDE includes a secondary reflected wave in addition to the forward-travelling wave. Impedance changes may be caused by physical non-uniformities in the signal trace itself (such as changes in trace width or direction), or by irregularities in the environment (such as ground plane interruptions or changes of distances to other traces).

6. *For the last 50 years, the pace of electronics development was set by the Moore/Dennard scaling "law". Discuss the "law" and its consequences, in particular its definition; its influene [sic] on performance, manufacturing cost, and power dissipation; and possible reasons for the end of its reign.*

   This is an essay-like question for which many answers are acceptable. For full marks, I'll be looking for comments on

   - the exponential nature of the scaling laws (a certain factor per year);
   - the consequential exponential improvements of performance and manufacturing costs, and the exponential power increases;
   - and reduced competition due to fewer leading-edge companies, together with higher investment costs and purely physcial limits due to atomic-scale feature sizes.