

GENERAL DESIGN RULES

Eight rules below are for *system design* in engineering fields

They are also applicable to many situations in **daily life**, including exams

How can We Deal with Complex Tasks ?

WE NEED TO BE IN CONTROL OF THE TASK !

Rule 1 : Remember that we are human beings. We are not machines ! Make sure you do not increase the pressure on yourself. You already have enough pressure ! Therefore, help yourself ! Do not rush ! Think !

The goal is controlling the design : **Who is in control ?** If **you** are in control (you are controlling the pace of the progress and deciding what to do next and when), you have a chance to complete the design successfully and on time since your technical knowledge and team work will be sufficient. If the **design** is in control, the chances of completing the project successfully is slim.

The remaining rules below help you ensure that. Prepare a plan that makes use of the rules below, stick to it and improve it if necessary.

Rule 2 : Simplify your task right in the beginning.

Do not deal with complex ideas, choices, decisions *initially*. Give yourself time to be familiar with what you are going to do. Give yourself a chance to like what you will be doing. Do not rush to the design. Some people **sleep on it**. Remember, if you are not motivated, you will not come up with a design as good as you would like.

Ask yourself these two questions :

- i) Am I familiar with the system I am going to design ?
- ii) Am I familiar with the design process ?

If you answered “No” to any one of them, you need to *help yourself* more. There are three ways to do that :

a) Investigate about similar systems/design processes.

See what others have done similar to what you will do. *Do the **background** (related work) search.* If related information is found, use it **if allowed**.

b) Dealing with a lot of details is frustrating.

To avoid many details in the beginning, use the top-down design method where you conceive of a number of “layers,” each describing the system in different detail. You order the layers such that upper layers have few details and lower layers have many more. You start the design with the top layer and proceed to lower layers. The bottom layer is the final design. The layered design approach relies on **abstraction** since upper layers, in their simplicity, abstract the system. This is also the same idea as thinking in terms of blocks. Thus, think in terms of blocks.

On each layer, the number of blocks (the amount of details) is different and increases as we proceed down. Once we define the blocks on a layer, we move down to the layer below and implement *each block* of the upper layer by using *a few subblocks*. Then, we move one layer below and implement each subblock by using a few subsubblocks, and so on. When, we reach the bottom layer, each subsub...subblock is a few gates, chips, wires, etc.

c) It might be a better idea to design just a representative piece of the system.

You may **not** be able to abstract the system. You may not be able to conceive of those layers. You may not be able to think of what each layer should be.

You need to gain *insight* ! Thus, rather than thinking about the whole large system, think of a “representative” piece which can later be expanded to the whole system quickly. Examples :

- ⇒ If you are asked to design a 64-bit ADDer, first consider designing an 8-bit ADDer. Once you understand how the design progresses, you can expand the design to 64 bits easily.
- ⇒ If you are asked to design a 8-bit up/down counter, first design a 2-digit up/down counter. In fact, you can first design a 2-digit up counter, then a 2-digit down counter, and then you can combine them. Again, once you gain insight into the design, the rest can be simpler than the beginning.

Rule 3 : Base your design decisions on a set of design goals (factors).

Do not make arbitrary design decisions : Be consistent. For example, do not just use a few high-speed chips here and a few slower chips there. Become familiar with design factors before you start the design and make use of these factors on each layer. Most commonly used design factors are **speed, cost, reliability, upgradability, maintenance, size, weight and power consumption.**

Rule 4 : Do not go for the design of an **optimal** system right in the beginning.

Rules 2 and 3 imply that we design a system that **works** and also **satisfies** design goals. However, doing both simultaneously especially as a beginner designer can create too much pressure on you. In these circumstances, relax Rule 3 a bit and just use Rule 2. *Once you have a working system*, then try to optimize it with respect to the factors you have in Rule 3. For example, design an ADDer that works even though it is slow. Then, modify it so it is faster as required by the speed factor. This design and optimize cycle can take a number of iterations, which is fine.

Rule 5 : Leave room for future expansions (upgrades).

Your design has to include “space” for future upgrades wherever possible. Otherwise, upgrading the system in the future can be quite difficult or impossible.

Rule 6 : Consider several layers at a time after you become familiar with the system/process.

After you become familiar with the system you are designing and with the design process, consider how each decision you make on the current layer affects the lower layers, in terms of the factors you determine in Rule 3. You now design the system on several layers **simultaneously**, which is not a top-down design anymore. This design is called **middle-out**. The advantage of using this rule is that it can avoid wasting time. It is possible that one partitions blocks in a certain way on a layer, assuming they can be easily implemented on the lower layers. But, when those layers are considered later, the designer realizes that is not the case. Then, the designer has to go back up to higher layers and do the design again.

Rule 7 : If you are stuck, do not know what to do next, stop...! “See where you are.”

If you do not know which sub...subblock to work on next, then see the big picture : Move up to the *upper* layers to focus on those **larger** blocks and see what you have missed. You will see which sub...subblock is next to implement.

Rule 8 : If you cannot explain something, why it happens as it happens, “go for the basics.”

Move down to the *lower* layers : There things can be explained in a few basic things (simple sub...subblocks). For example, if the ADDition time is too slow, focus on the carry_{out} circuits right away.