

Electronics HW Design Process – Architecture

I typically do not start any development work without having at least a combined requirements and architecture document. Hence, I consider having an architecture a crucial stepping stone in product development. BTW, I discussed requirements in a previous article. The architecture takes the requirements and figures out the next level of detail implementing them. The earlier any issues and conflicts are brought to light in a product development, the better, saving much time, resources, and development costs. Writing an architecture document provides several additional opportunities that are further discussed in this article.

Refining Requirements

Chances are the requirements you received or you developed are open to interpretation to some degree. When multiple stakeholders contribute to a number of different requirements topics, it is likely not all of them have the same interpretation to the words that have been written down. Through architecting the product at this stage your stakeholders can verify if your interpretation is correct or if the requirements need to be updated to provide more clarity. It is also possible in the architecture phase that you come across conflicting requirements which in their current form cannot be accommodated in the product design. The architecture therefore can help to clarify which requirements get to be implemented, which need to be modified, and if new requirements need to be added.

Feasibility

The architecture phase is the time to figure out if and how feasible your given requirements are. If a particular requirement cannot be realized, this is the time to go back to your stakeholders and present the issues at hand. The issue may or may not be a technical one. The issue I often ran into was a desired product cost versus my initial rough calculations of the cost of Bill of Materials (BoM). It needs to be clear what's realistic and feasible before starting the more labour-intensive portions of the product development. This could lead to the product development being stalled, needing to be redefined, or in the worst case being cancelled. This, however, is overall a better choice than to continue and be faced with that choice at a later time.

Design Choices

There may be more than one way to implement the requirements in your development. The architecture provides an opportunity at a higher level to weigh the pros and cons of a particular implementation strategy. Discussing the impact of each strategy on the overall product requirements can be tremendously helpful in finding the optimal implementation. Presenting the architecture and design choices to stakeholders may reveal "hidden" requirements not revealed earlier and hence lead to other discussions and choices.

New Opportunities

It has happened to me more than once that the architecture phase presented some new options and opportunities for the project. Immersing myself into relevant technologies and researching solutions often allow for alternate creative solutions to be considered. It is helpful to discuss these new ideas and opportunities with primary stakeholders in order to ensure the anticipated solutions are still the best ones going forward.

Having a Written Document

I believe it provides great value to have an actual document that discusses the architecture and summarizes the best path(s) forward. It prevents me from questioning myself in later design phases and it allows sharing the gained knowledge with other parties, stakeholders, and the development team. Many times, this has led to great discussions improving one or more design aspects. Overall, it creates the clarity and focus needed for efficient design work to take place in the next phase of the product development.

Tip: I write the actual document while researching and investigation all the different aspects of the architecture itself. I find that it does not add much time to write down what I am doing and as far as my brain works, it has always helped me to stay more organized and focused. I often have used my own documentation to refresh my memory about design intent, design details, or when I or others needed to make design changes down the road.

What to Include

Here a list of possible sections to include in your architecture document.

- References to the actual requirements
- A list of critical requirements that will be further investigated in the architecture document (this list may get edited more than once while writing the document)
- A risk assessment as any perceived design risks should be discussed prior to starting design activities; the further ahead you get the more you want to avoid risks
- A list of recommendations based on the research and analysis completed as part of the architecture
- One or more technical block diagrams. The block diagram(s) should provide a good overview of the different aspects of the design allowing a 3rd party to easily understand the design intent. A picture can be worth more than words.
 - Features and functions with their logical location (e.g. which PCB)
 - Connections between hardware and/or functional blocks including any IO
 - Detailed functional blocks and flow (on and between PCBs); if known this can contain intended component part numbers to be used for each functional circuit
- Results from research, trials, investigations, prior implementations similar in nature
- Preliminary product 3D renderings and industrial design ideas if available with a discussion of the design impact different ideas may have

- A discussion of materials used in the product
- A discussion of detailed circuit design aspects and component choices (point out any risks to investigate either here or in a preliminary design review step)
- A discussion of cost and BoM cost
- Any critical components, assembly steps and its potential impact on manufacturing
- A rough layout of the circuits and components (I often do this in Visio) to verify PCB size, fit, and form; this also goes to feasibility meeting the required product dimensions

I find it important to reveal as much in an architecture as possible and useful. This lowers the possibility of surprises when stakeholders see the results of the requirements and architecture in the following design implementation phase (for instance detailed schematics and layout, 3D rendering of mechanical implementation, and so on). Going backwards is costly, but the sooner you can backtrack the better.

When I was working for a consulting firm providing design services to 3rd parties we started to discuss the need to provide greater implementation details in the architecture with the benefit to mitigate and lower risks in the actual implementation of schematics, layout, and mechanical design. We were thinking of going as far as defining any critical circuits in full detail without necessarily the use of a schematic entry tool. This avoids translation errors from the architecture to schematics, layout, mechanical design, etc. since the architect may not be part of the implementation team.

Other companies have a preliminary design review step in their design process, working out some of the critical requirements in greater detail to mitigate taking too much risk into the detailed design phase. In this case the architecture may not provide as much detail, but identifies any areas of risk to be investigated as part of the preliminary design review.

Manufacturing and Supply Chain Management

As a designer you are responsible to ensure all materials and components used are readily available in small prototype as well as large production quantities. In electronic HW design you also need to be sure the components and their footprints are correctly entered into the schematic and layout tool. Correct mechanical representation of each component is important for accurate 3D modeling of the PCBA.

Ensure you have had early discussions with suppliers, purchasing, manufacturing, and component engineering to avoid surprises down the road.

Tip: Many Contract Manufacturers (CMs) have readily available documentation and design guidelines answering many of the questions you may have.