Best Practices in Embedded Systems Design

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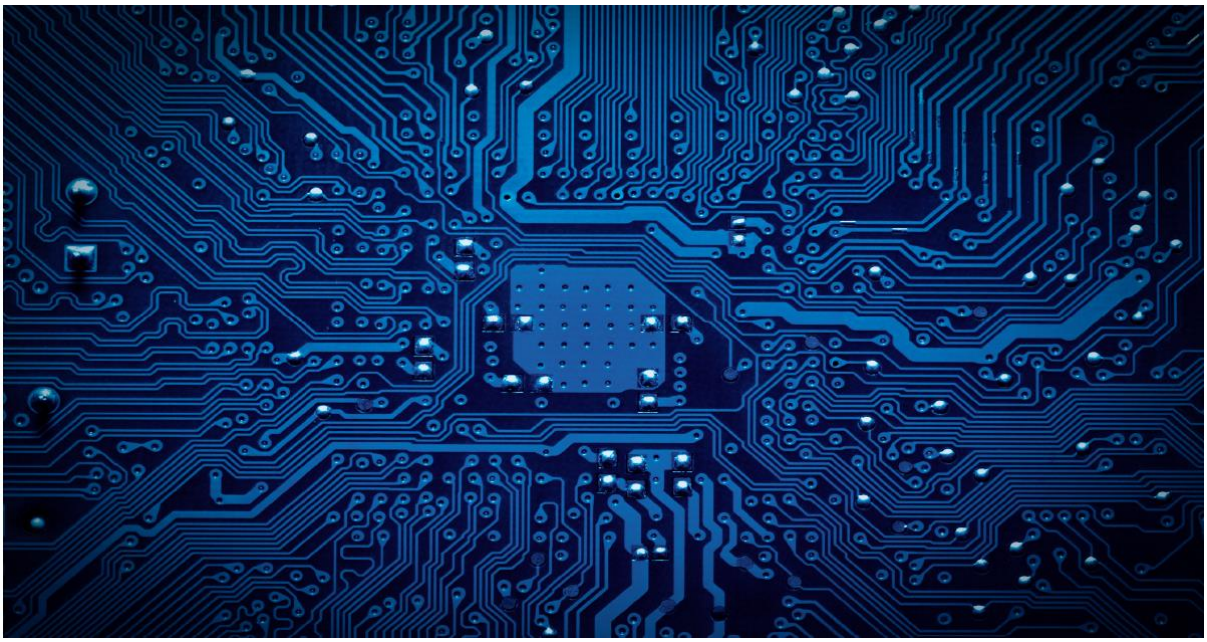

Product design and development is becoming extremely complex with many factors are to be set right – functionality, aesthetics, manageable cost of production, scalable connectivity, security, and many more. The risks are higher and significant when we are designing and developing tiny, specialized systems that power personal gadgets to industrial equipment.

It takes years of specialized expertise in embedded system design & development to identify and apply best practices that addresses the challenges such as overheating, ensuring adequate computing power & memory, energy efficiency, prevention of data loss, plugging the security vulnerabilities, easy to bulk manufacture, optimum cost, quality, regulatory & safety compliance, and consistent high user experience etc. Let us examine some of the best practices to specifically address few of the critical challenges in embedded system design.

Design for Optimum Power

There are many factors to consider predicting the power requirement for your embedded system. One of the best practices is to factor and plan the power requirements into your design right from the start. An experienced designer is equipped to predict the energy requirements of their products accurately and will ensure it gets built into the final design.

Using a processor with adequate processing power will ensure that the product works as intended with minimal or no lags or delays. This will also ensure upgrades and scalability aspects of the product during its lifetime.

Design for Optimum Memory

Having adequate memory is critical for the correct functioning of the embedded systems. Planning and designing the system with correct and sufficient memory is critical to avoid performance and other related issues. Memory upgradability is a must have feature in the modern-day embedded designs.

In small embedded systems where SOCs are used (system on a chip), the amount of available memory is fixed. During the firmware development, care must be taken to optimally utilize and reuse available resources. Applying special data structures and memory allocation algorithms are some of the best practices that can be leveraged.

Address overheating issues

Overheating is one of the biggest challenges in an embedded system design. As embedded systems are extensively used in critical areas from healthcare to manufacturing, malfunctioning due to overheating cannot be afforded. There are different ways to design a most suited cooling solution. Using fans to circulate air around is one such approach. Some designs use heat pipes or specialized heat sink etc.

Prevention of Data loss

Embedded systems are vulnerable to loss of data as it often uses volatile memory and hence data can be lost in situations such as a power failure. There are many design considerations that can be considered depending on the criticality of the application, that prevents data loss such as using EEPROM for critical data or having a real-time connectivity to a backup service either locally or on cloud.

Security vulnerabilities

Embedded systems are to be constantly monitored and upgraded to plug any potential threat from external interferences. Several best practices can be leveraged to make your embedded systems secure. Design approaches such as implementing encryption technologies in the interface designs, provision to securely upgrade the firmware with authentication using encrypted private keys are few examples. As part of the development process, continuous rigorous testing and auditing of both hardware and firmware components to identify potential vulnerabilities and resolving them will help deploying a more secure system later. To make the systems secure, a constant and concerted effort is required both from a technical and organizational perspective.

Design for regulatory compliances

Today the usage and integration of embedded system is growing exponentially. Many regulatory and safety compliances are being prescribed and made mandatory across the globe. Embedded systems are to be designed right from the early stages itself for regulatory and safety compliance such as FCC, CE requirements as well as safety requirements such as UL and European Safety Norms.

Ease of Manufacturing

As world become more and more connected, embedded systems are used almost everywhere. Hence it is very important that the embedded systems are manufactured at scale. As the manufacturing difficulty increases, the systems become expensive and could limit the market potential of the products and associated services. As embedded system designers, we need to keep the manufacturability of the system in mind at the design stage itself. Reducing the design complexities

by focusing on simplicity and the number of components involved would help manufacturing to be simpler, affordable, and streamlined.

Optimization of cost

A cost optimized design is critical for the success of the embedded system and associated products & services. There are several factors contribute to the cost of a system such as hardware & firmware complexity and inferior resource management leading to higher resource & labor costs. Detailed planning with attention to details will help us avoid these pitfalls. Strict focus on efficiency and retaining only the most essential features will help us to make our product cost-effective without any compromise on quality and performance. A cost optimized and simplified design approach right from the beginning will lay the foundation for an affordable high-quality system.

Quality Challenges

As the world is getting increasingly connected, user experience is critical. Poor quality of performance by one of the systems is enough to frustrate the users, as these systems are increasingly relying on complex hardware and firmware working in tandem. To ensure high-quality systems, the designers and manufacturers must focus on every aspect of their design process, continuously benchmarking their methods to deliver and improve efficiency. A strong design partner will help companies to deliver excellent quality systems.

Impact to environment

Embedded systems could cause severe pollution and resource wastage. Every successful product should focus on minimizing wastage and reducing carbon footprint at all stages of production. Best practices such as leveraging of recycled material as much possible, investing in energy-efficient technologies, and using environment friendly or reduced packaging. This requires careful planning and consideration to our environment.

Standardized design approach

The need for focus on a standardized embedded system design and development is becoming increasingly essential in this connected world. There is a constant push for upgrades and newer versions of products and platforms. Compatibility to other systems in a connected world becomes a major issue for system designers and developers. Development of use case specific guideline for interfaces between systems and platform is needed. Better collaboration between design and manufacturing teams will ensure long term reliability for the end-users.

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