SIEMENS DIGITAL INDUSTRIES SOFTWARE

Digitalizing the systems value chain

How Siemens will help you engineer a smarter future faster

Executive summary

Digitally transforming how the electronics value chain is traversed will unlock the full innovative potential of system design companies all over the world. This paper discusses how the cloud will change the way design teams create next-generation products, and how this will facilitate and optimize companies' digital transformation. By augmenting desktop authoring tools with integrated, native cloud applications that seamlessly connect companies with the electronics value chain, design teams will be empowered to confidently deliver on aggressive requirements, schedules, and budgets.

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Introduction

Innovation is the driving force behind the market growth seen in the electronics industry. To deliver innovative products to market on time, product development teams at system design companies depend on a robust ecosystem consisting of component manufacturers, component suppliers, PCB assembly partners, design service companies, and others. Together these form the electronics value chain that links your company to component suppliers and electronics manufacturing.

The most successful companies at consistently delivering products to market on time, on budget, and on requirement are constantly seeking ways to tighten the links to their partners in the value chain. They know this is key to improving their overall digital transformation (and overall profitability). The realities of the pandemic have laid bare the frailties of global supply chains and of businesses that do not have a robust digital presence.

What does it mean to have a robust digital presence? Imagine a world where you could design-in supply chain resilience. Where complexity of next generation components could be more easily simplified, digested, and designed-in, with system integration and performance predetermined. Where a comprehensive repository of high-quality model content (e.g. eCAD, smart 3D, simulation) is accessible via a simple keyword or parametric search. Where collaboration with suppliers, partners, and contractors is intrinsic and seamless. Where you could design confidently for first-time success. Imagine having that intelligence and control at your fingertips as part of one fully integrated electronic systems design solution.

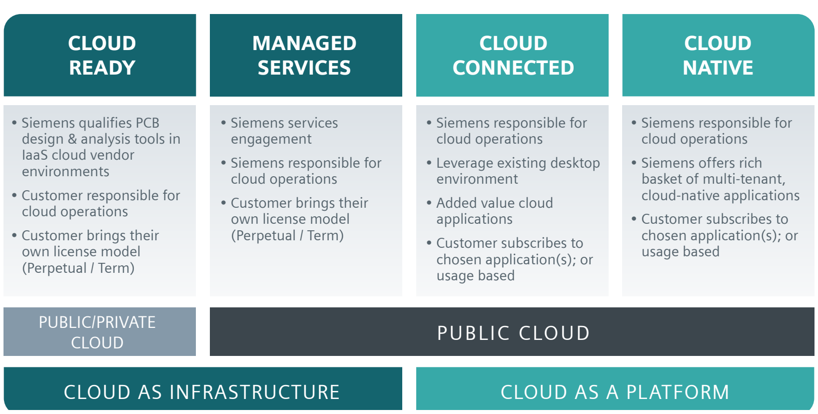

Figure 1. The four pillars of the Siemens EDA cloud enabled solutions for electronic systems design.

The Electronic Systems Design and Manufacturing segment within Siemens EDA, a part of Siemens Digital Industries Software, can make that world a reality for your company, so you can bring tomorrow's designs to market today. We are dedicated to delivering a continuum of cloud-enabled solutions that unlock the full potential of a digital transformation for our customers, in their way and at their pace. Our strategy is founded upon the four pillars:

- Cloud Ready
- Managed Services
- Cloud Connected
- Cloud Native

The four pillars were introduced in the Siemens whitepaper, Lost in the Cloud? Siemens Shows the Way[1].

In this white paper, we'll take a deeper look at the cloud-connected and cloud-native pillars; specifically, how the cloud will change the way design teams create next-generation products, and how this will facilitate and optimize your digital transformation. By augmenting desktop authoring tools with integrated, native cloud applications that seamlessly connect your company with the electronics value chain, design teams will be empowered to confidently deliver on aggressive requirements, schedules, and budgets.

The evolving digital journey of the electronics value chain

Although design files continue to be stored on network drives and shared via email and FTP, the electronics value chain has evolved considerably over the last 25 years. Shelves filled with data books have been replaced with easily accessible/downloadable PDF files. Product selector guides have been replaced with parametric searches using powerful, vertical search engines hosted by design and supply chain aggregation websites. Desktop EDA tools have become more powerful and automated—including analysis and verification of complex functions such as signal integrity, thermal, and manufacturability. For manufacturing, multiple files for each function and machine have moved to a single product model based on standards that all EDA tools output and all manufacturing machines recognize.

However, even with these advances, chasms remain, separating product engineering teams from their partner stakeholders in component supply and electronics manufacturing. The problem isn't a shortage of powerful tools or lack of access to copious amounts of useful information; the chasms persist due to four absent or inadequate factors:

- A trusted and traceable digital twin of an electronic component (think digital data sheet) that is directly consumable by downstream tools and useable throughout the product creation lifecycle
- A workspace where complex components can be discovered and explored quickly in a system context
- A collaboration cockpit that securely connects cross-functional design teams with internal and external stakeholders all along the value chain based on the single source of design data.
- Access to component intelligence and models, accelerating product realization directly from the EDA tools
- Cloud-aggregated training models that bring the experience of many design years to the fingertips of engineers[2].

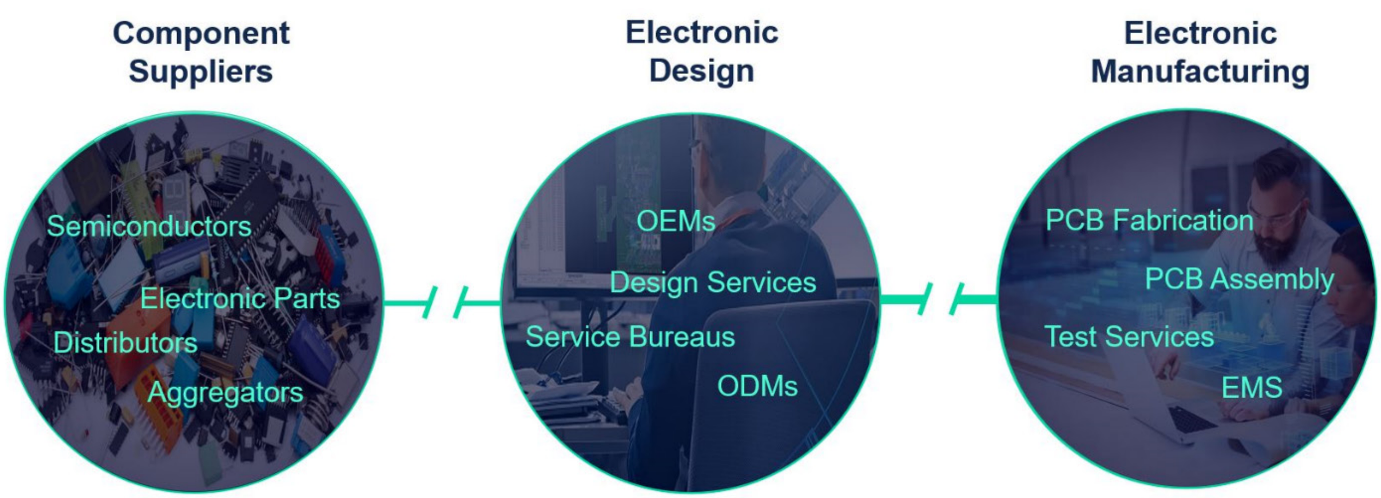

Figure 2. Today's electronics value chain

Companies have established methodologies and created roles to compensate for these inefficiencies in the value chain. But even with the best intentions, these methodologies—which vary from company to company and more broadly from small to big companies—are merely expedient, temporary measures for persistent, systemic issues. How can it be, for example, that 45% of projects are still either delayed or never see the light of day[3]? How can it be that an inordinate amount of time is spent searching for PCB related content and aligning the team with the correct version of the design under development? How can it be that even when a product design is complete, the product's introduction can be delayed considerably due to supply chain related issues?

Consistently, as shown in recent Aberdeen studies, "time" and "cost" are the #1 pressures facing companies[4]. The last year highlighted the wild variability of the component supply chain, grossly extending lead times for consumer electronics-dependent products. Companies relying on the end-of-year holiday season for the bulk of their sales are massively exposed to the ebbs and flows of the electronics supply chain, which is now all too common across all end markets, not just consumer electronics. Risk is further inserted when the void for a component shortage is filled with suspect semiconductor components including counterfeits. Personal anecdote: a generic 2021 SUV purchased in May had a 28-week lead time due to a shortage of an electronic sub-assembly.

And these conditions are aggravated by the increasing complexity of each successive generation of electronic products, by the underlying components used, and by the high expectation placed on processes and organizations to bring a successful, new product to market on time, on budget, and on requirement. Further digital transformation is vital to eliminate the inefficiencies and delays that lead to cost over-runs, while mitigating the risks that impede the innovation necessary to fuel top-line revenues and achieve operational excellence.

How Siemens will help you engineer a smarter future faster

Siemens EDA's Electronic Systems Design and Manufacturing segment fully understands how to bridge the chasms in the electronic product creation value chain. Our solution will effectively hard-wire your company to component manufacturers and suppliers as well as design and manufacturing services via a high-bandwidth digital thread, completely enabling access to an open and flexible ecosystem for electronic systems design.

Collaboration is intrinsic to the solution. It is supported at every step of the design process with the flexibility to securely manage the handshake between stakeholders (internal and external) throughout the value chain.

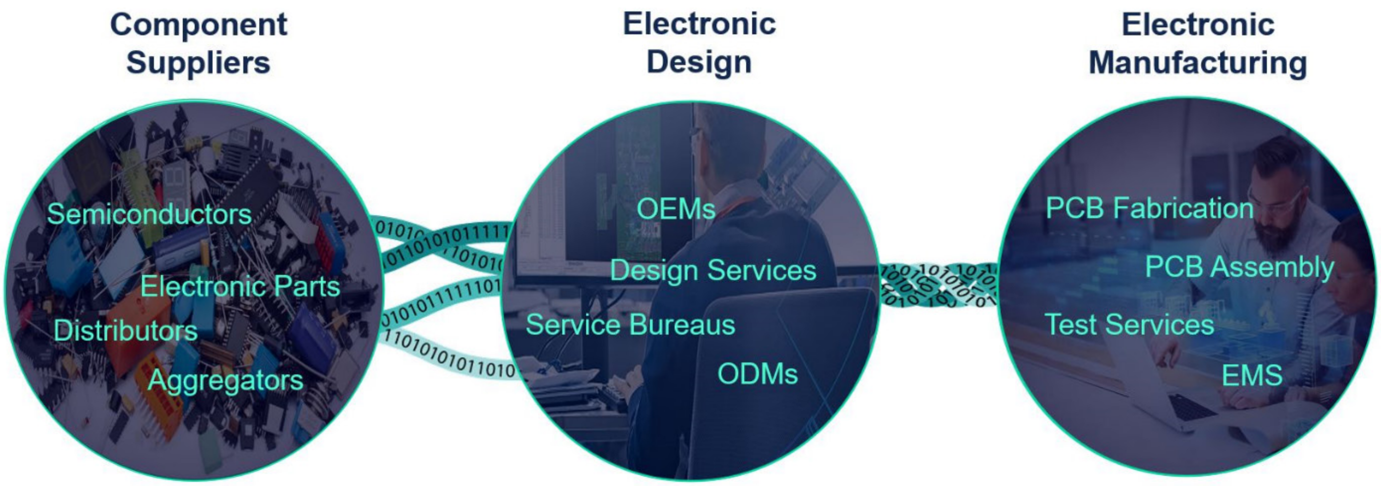

Figure 3. Digitally transformed electronics value chain

With the tools to more productively collaborate and with greater visibility into and integration of component intelligence—for purposes of research, exploration, and sourcing—this solution will enable greater strategic decision capacity at every point in the design process. It will streamline the design process by shortening dependencies. It will improve first-time success rate by reducing the risks that accumulate in the form of time delays and human error throughout each step in the product lifecycle.

This will be achieved by building onto existing EDA tools and infrastructure already in place and then leveraging the cloud to integrate, augment, and amplify the power of those tools into one unified user experience and flow. In time, one fully integrated collaboration cockpit will emerge that will span the complete electronic product creation process. It will connect all the players in the value chain through a common digital thread derived from standards-based digital twins of components, and it will seamlessly unite them with other design domains such as mechanical and electrical (cabling/harness).

Let's look at the important functional elements of an integrated solution that leverages the cloud, is based on a common digital thread, and promises to accelerate electronic systems design.

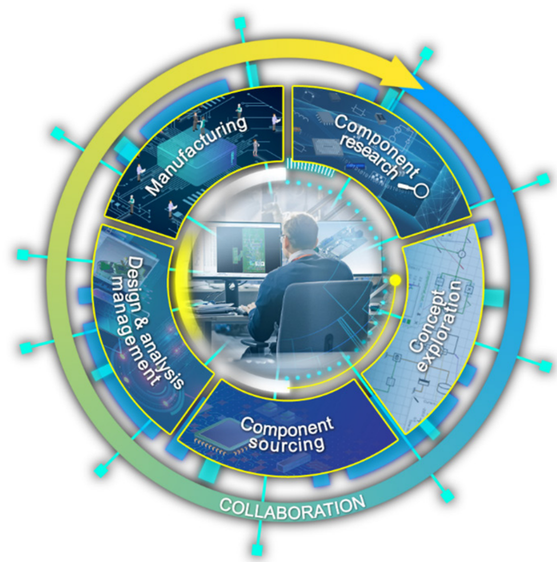

Figure 4. Electronic design solution

Optimizing Component Research

The component industry for electronics is very dynamic. The rapid innovation seen at an electronic product level is fueled by advances in component technology and packaging. The rate of new component introduction is exponential, with a flood of newly released parts offering broadening functionality, higher performance, lower power, smaller form factor packages, and more. Engineers wanting access to new(er) technology need direct access to powerful search engines that scan the comprehensive pool of available industry components based on specific parametric requirements or via simple keyword searches.

For example, at a base level, if an engineer simply types in "lithium-ion battery protector," the search should return all components offering lithium-ion battery protection. Likewise, if an engineer wants to find the smallest, active 700mV Schottky diode at an I_f (forward current) of 1A and with formed leads, the search should return a list of all potential candidate devices on the market for easy comparison or for additional filtering (e.g. to pick a preferred supplier).

However, at a more beneficial level, the component research in a transformational solution will include training models based on aggregated historical information that would recommend viable options to narrow the search. If a processor is selected, for example, the machine learning model would predict the other components needed based on historical knowledge. In the case of the "lithium-ion battery protection" search mentioned above, it will even suggest alternative implementations from a fully integrated device to potential FPGA alternative approaches. The focus will not only be about picking the best part, but also about building a better product.

Component research needs to also consider what's readily available in your corporate central library. In other words, the same parametric search criteria used in the examples above would not only return results from the comprehensive pool of all available manufactured parts but also parts matching the search criteria in your company's existing central library. This brings all the relevant data to the fingertips of engineers, empowering them to make more informed component selection. Moreover, the results of the integrated component research solution will be optimized to a customer's specific value chain.

If some components are selected that do not appear in the corporate central library, online access to high-quality, pre-made eCAD models (symbol, footprint, and smart 3D), constituting billions (10^9) of PCB-mountable parts, will be readily available. More importantly, the symbols that are drag and dropped to the schematic canvas would be pre-configured to the user's settings (grid size and units, reference designator location, font size, terminal spacing) and include all the desired parametric properties. No manual entry would be required. Footprints would conform to the latest IPC standard or could be simply configured to custom rule values securely defined by the user. And smart 3D models automatically orientate models to correctly align terminal pins to pads.

Component research can be done at a single-part search level or at a bill-of-material (BOM) level. In the case of imported BOMs, a use case is an engineer wanting to create a library from scratch. Upon BOM import, a bulk search ensues, and a project library is created and populated with all available parametric information for each part in the BOM, including the associated symbol, footprint, and smart 3D models. This use case allows you to drag and drop the completed project library, in part or in bulk, to the design schematic.

This is component research made easy, with integrated access to parts libraries from a variety of sources, freeing engineers from expending time and energy on non-value-add tasks. Hardwired to the trusted digital thread, component selections are traceable to the source so part change notifications (PCNs), for example, become automatic rather than another search requiring independent attention and follow through.

Optimizing Concept Exploration

As we've said, electronics, whether they be the brains behind your smart device or a new autonomous vehicle, have become more complex. The systems are more complex, and the underlying components are more complex. Today, even traditional "analog" components are becoming more "digital," adding programmability, state machines, and other advanced features that are beyond the capabilities of existing analog design tools. Understanding this complexity has become essential.

Circuit and system engineers need a workspace to explore new complex parts, to dive deeper into a new technology they don't fully understand, and to examine the interactions of their circuits with external "mechatronic" elements. Such a workspace will help them better calibrate overall performance of their design and reduce the all-to-frequent discovery of problems during system integration.

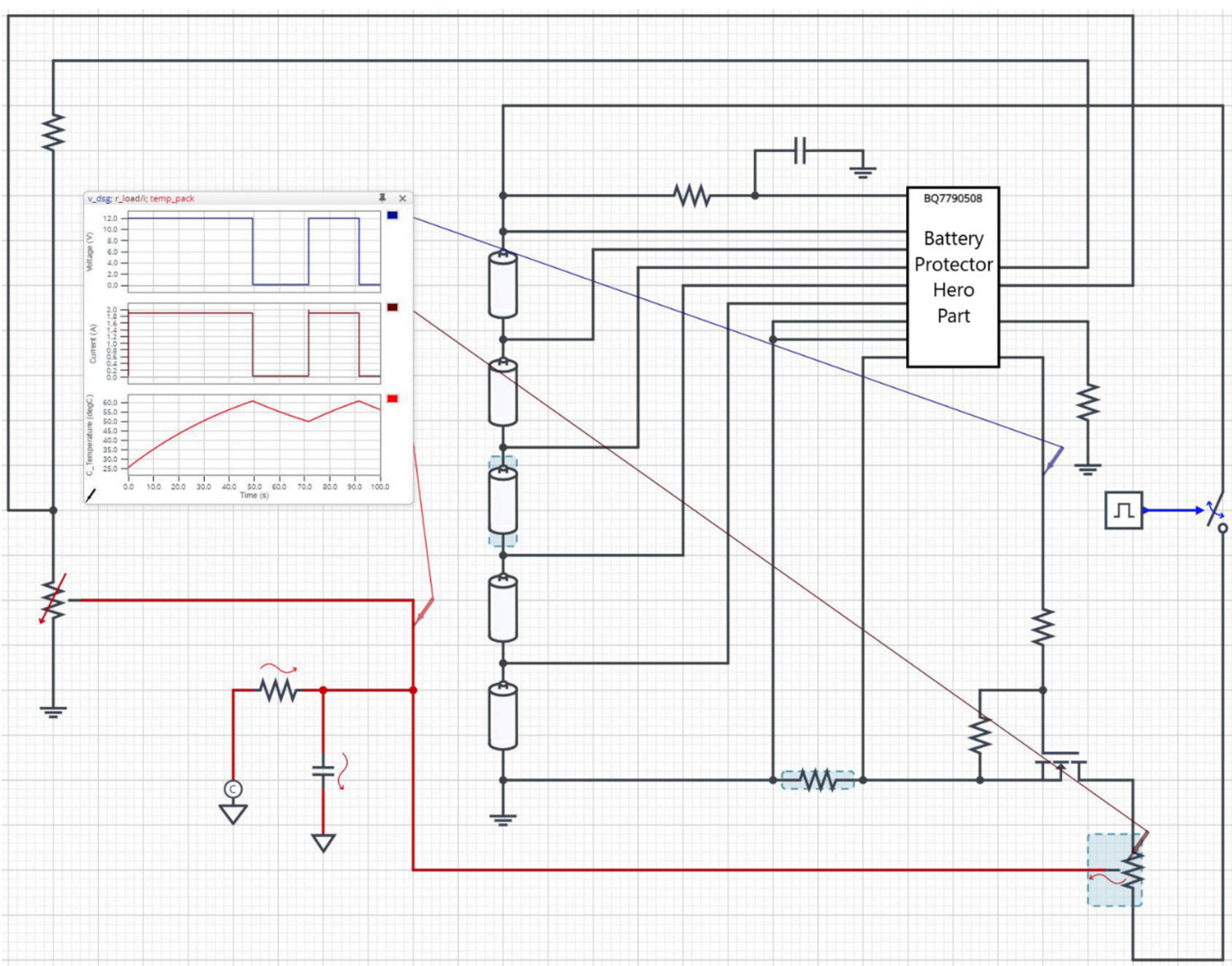

Figure 5. Lithium-ion battery protection generic circuit

Let's look at how this works in an integrated ecosystem solution. In the simple "lithium-ion battery protector" search referenced in the section above, multiple components are identified. Let's suppose that the circuit engineer that did the search is designing a new cordless hand-drill. One of the components found is interesting, because it appears to be a fully integrated component that provides various protections against over-voltage, over-current, and over-temperature. Along with the parametric specs of the device, it comes with an interactive application circuit that enables the circuit engineer to explore the capabilities of that part in more detail.

By changing the parameters of the load in this generic circuit to match the hand-drill environment more closely, the circuit engineer can graphically see the changes to the temperature, voltage, and current responses. The circuit engineer can also see the limits in which the hero part will trip and shut down the operation to protect the lithium-ion battery from damage.

Now that the circuit engineer is satisfied that this integrated component provides multiple protections and is confident it should work in the new cordless hand-drill design, the application circuit is opened in the cloud design workspace for customization to the specific requirements of the hand-drill application. The generic parts of the circuit are replaced with parts that are intended to be used in the final product, including inserting a motor, motor drivers, and switches. For example, a new search within the design workspace would turn up an appropriate MOSFET to perform the function of the motor drivers.

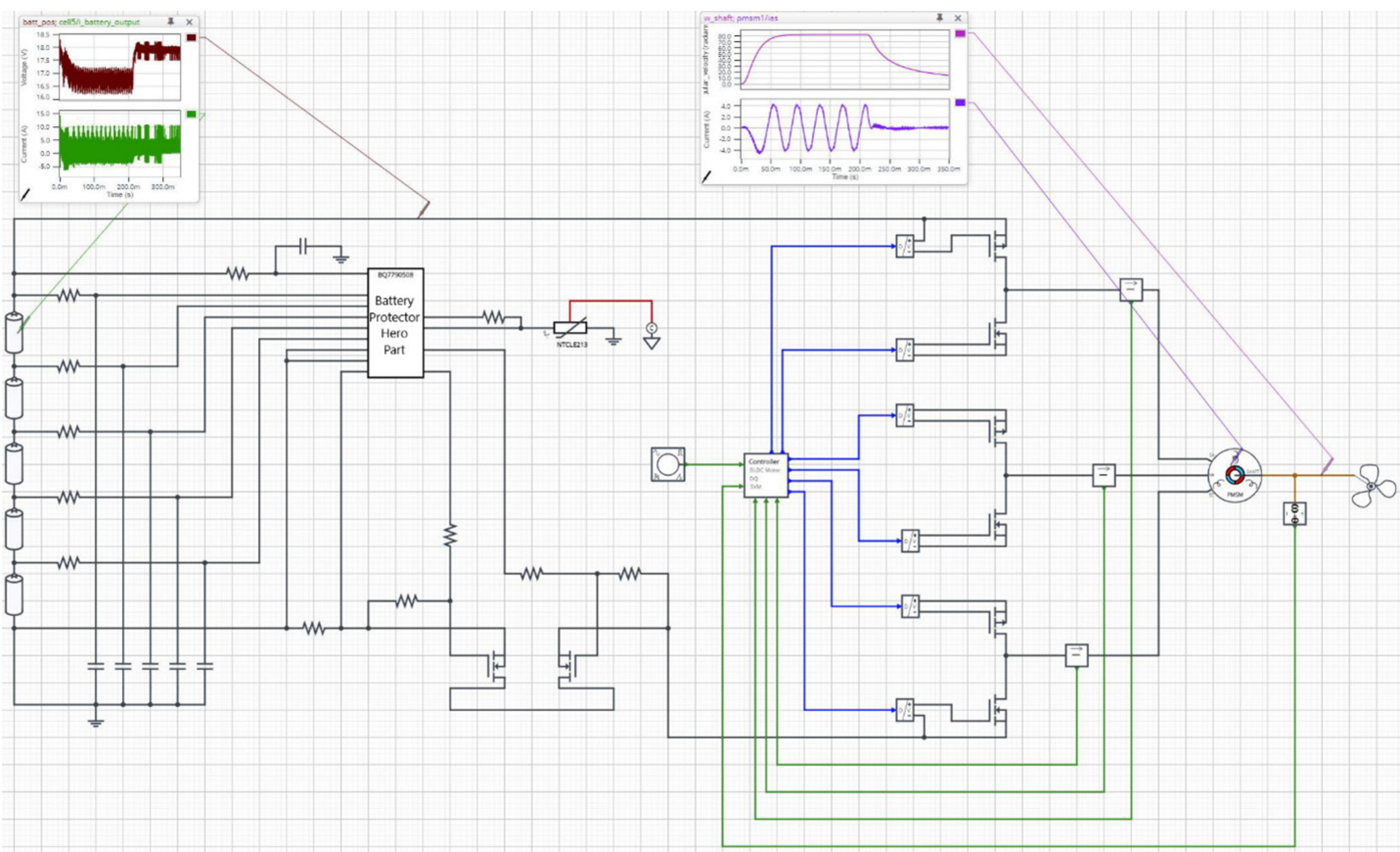

Figure 6. Final lithium-ion battery circuit matching hand drill design requirements

The circuit engineer verifies the added components by running simulations specific to that hand drill's application requirements. The intention now is to validate the functionality of all these critical interacting components before committing this sub-circuit to the final design.

Once the design is validated to function correctly, the functional block is ready to be integrated into the schematic of the full design, which is made easy using the integrated electronic design solution.

By connecting ideas with implementation, exploring complex problems is made easy. Integration coupled with subject matter enlightenment and supply chain visibility empowers design teams to make early decisions about hero parts, avoid costly design errors, and ensure product performance.

Optimizing Component Sourcing

The BOMs for electronic designs can include a small number of components, hundreds of components, maybe even thousands of components, but it only takes one component to derail a product launch. Maybe the part isn't immediately available (extended lead time)? Or worse, maybe the part is obsolete or isn't compliant to an environmental requirement of a target end market? The dynamics of this reality result from many different factors. Shifting geopolitical pressures, trade policy, weather-related impacts, and global health crises are contributing factors to component sourcing volatility (both cost and lead time). This has greatly disrupted the ability of companies to stay current in an ever-evolving supply picture.

The answer to this volatility is contained in the fully integrated electronic design solution. Instead of static BOMs maintained in spreadsheets at the heart of any product design, real-time component sourcing intelligence is at the fingertips of all stakeholders responsible for bringing a successful product to market. For example, during part selection, component sourcing intelligence will be as readily available to engineers as the functional parametric information needed to assess technical fit. At the point of schematic design, the same component sourcing intelligence will be immediately available to confirm confidence in part selection. At the BOM level, the same component sourcing intelligence will be directly available to all stakeholders for cost analysis, scrubbing for sourcing risk, and grading. At every step, equivalent or alternate components will be presented at a functional level or at a more refined form/fit function level. The objective: real-time visibility of consistent component-sourcing intelligence at every step ("gate") of the product creation journey, from component research and exploration to manufacturing, so the most informed part decisions can be made and NPI risks reduced or eliminated.

This component sourcing intelligence converts supply chain data into actionable insights so your company can remain resilient without sacrificing innovation or producing adverse business impacts. It is a certain solution for an uncertain world. Siemens' acquisition of Supplyframe[5] in May 2021 and their Design-to-Source Intelligence (DSI) solidifies our #1 solution-provider position in supply chain resilience.

Optimizing Design and Analysis Management

Tightly knit collaboration among development teams, co-workers, and partners has become necessary for bringing a successful product to market. The cloud offers a new transformative option, based on the single source of design data, for cross-functional teams who want a collaboration hub that includes design and analysis management. This important element of the integrated ecosystem solution is detailed in the white paper, Tacking to Win: Connecting Teams with a Collaboration Hub in the Cloud[6].

The strength of a collaboration cockpit is the ability to optimize product design. This starts with the expertise of the individual product design engineer. However, the collaboration cockpit enables the shared experience of the broader design team based on direct collaboration and the aggregated knowledge built into machine learning models from previously completed design experiences. Taken to another level, the collaboration cockpit will also enable cross-domain (e.g. mechanical) and partner (e.g. EMS) collaboration that will also benefit from the resultant aggregated historical cross-domain knowledge. The potential of concurrent co-design with other product stakeholders is taken to a whole new level. The result? A better product design, delivered to meet aggressive schedules, and set up for first time success.

Optimizing the Handoff to Manufacturing

Notwithstanding the supply chain element of this process (which is covered in the "Optimize Component Sourcing" section), one of the common challenges in the handoff from design to manufacturing is the disconnect in knowledge, data, and communication between designers and manufacturers. This lack of direct connection too often leads to project delays as designers find out late in the process that the design does not comply with the manufacturer's constraints. Shifting-left manufacturing knowledge to the physical design phase is a key element of an integrated ecosystem solution. Let's discuss how this should work.

With the physical design complete, the ODB++D board design is loaded to an integrated cloud app. The manufacturer's unique capabilities or the more generic industry-standard manufacturing capabilities are then selected to perform a design for manufacturing (DFM) analysis, where the design gets checked against specific manufacturing constraints. For example, maybe a component lead extends too close to the edge of the pad and solder paste, resulting in a poor solder joint. This feedback would allow the library footprint to be properly adjusted for that component before handoff to manufacturing. For further benefit, data aggregated during manufacturing is connected back to designers, providing real-time manufacturability information when they are researching components.

A dashboard is available for easy review of results. Here a designer can see a summary of the different technology parameters of the product, such as layer

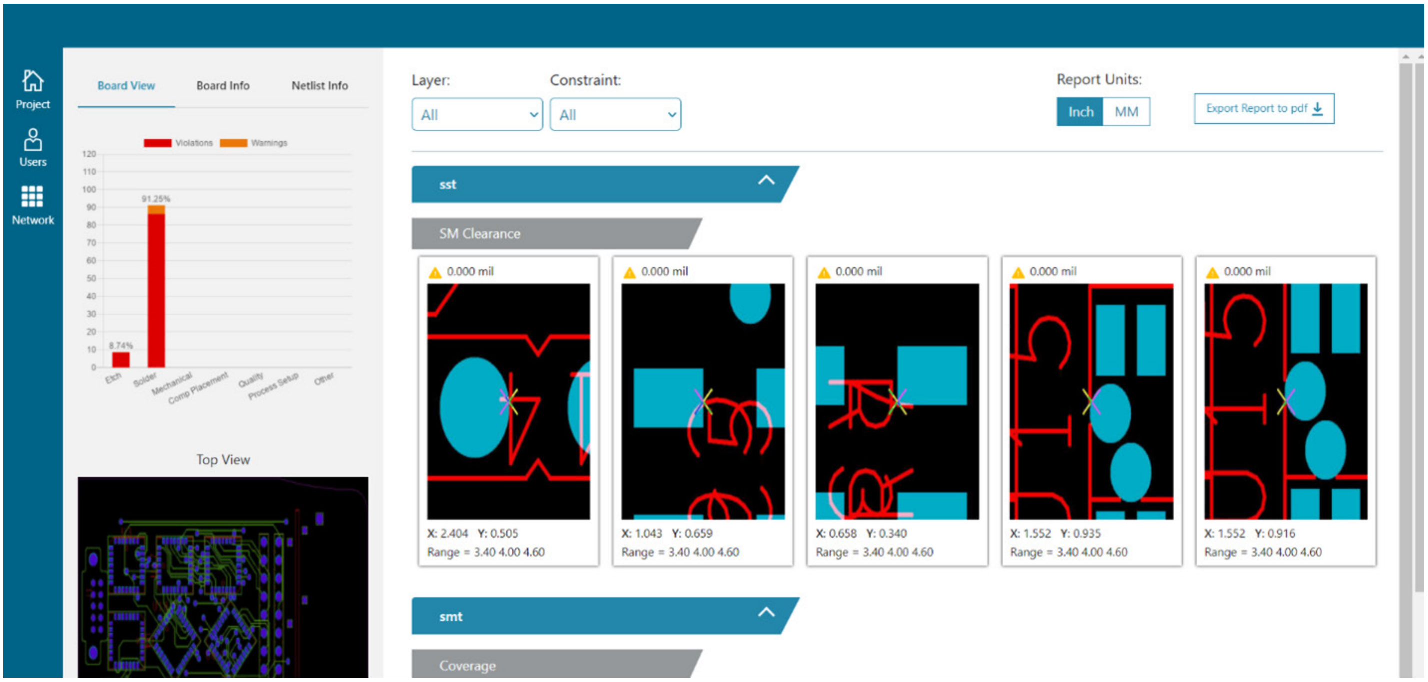

Figure 7. Dashboard of DFM analysis report

count, board thickness, part count, and other data, that helps determine the technology class of the product. This is extremely important to a DFM/ manufacturing engineer, because it is typically the smallest part on the board, the part with the finest pitch, and the part mounting technology that will determine the type of manufacturing process that will be used to build the product. This determination assists the designer in selecting the correct set of manufacturing constraints that must be complied with for the design.

Armed with this information, the DFM engineer can seamlessly analyze the design against the selected manufacturing constraints and review the results. The designer can quickly assess discovered violations and see breakdowns between what are considered just minor warnings (recommendations) versus critical violations. The DFM engineer can filter the violations based on layer or constraint type, depending on the phase of the design process. Measured values will be assigned to each violation, which can be compared to the critical and recommended rule values. The DFM engineer also has direct access to information that shows the exact measurement being taken, accompanied with a detailed description of the manufacturer's rule. Bulk fixes to similar violations are easy and efficient. For example, an adjustment to solder mask clearance can be applied across the whole board design.

With this important manufacturing information available at the point of need, the designer is now empowered to confidently make changes that will ensure first-time success before ever releasing the design for manufacturing on time, on budget, and on requirement.

Optimizing Trust and Traceability

Per previous mention, successfully bringing an electronic product to market is riddled with challenges. Complicating matters is the vulnerability of the supply chain. For example, advanced 3D printing technologies enable malicious players to produce convincing component imitations of original packaging and labeling, allowing counterfeit products to enter the supply chain. This challenge has been around for years, but it is becoming more acute and brazen. Left unchecked, the issues resulting from counterfeiting, tampering, and diversion will continue to rise.

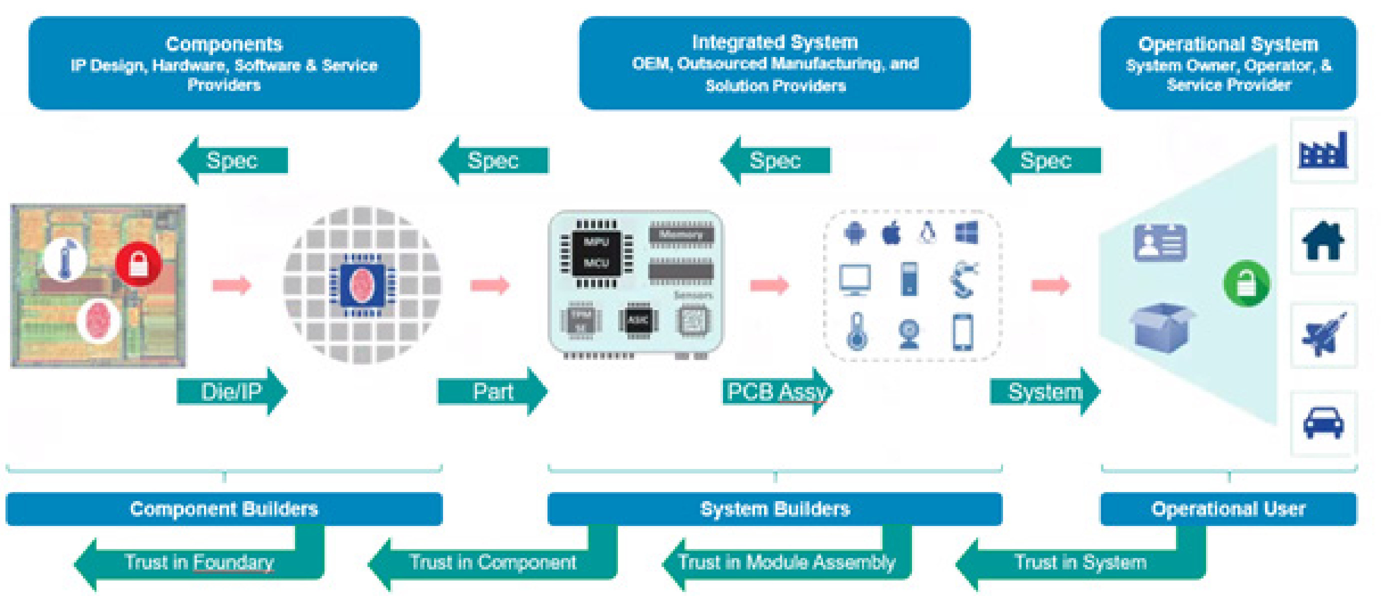

Figure 8. Data trust requirements in a complex ecosystem

Fgure 8 shows the complexity of building trust in a complex ecosystem and its supply chain. Our vision is to ensure trust and traceability throughout the supply chain and design chain.

Conclusion

Digitally transforming how the electronics value chain is traversed will unlock the full innovative potential of system design companies all over the world. With Siemens EDA, your company can optimize not only your systems design process but also every link to the stakeholders in the value chain to achieve higher levels of digitalization and profitability. What's more, in the future you can achieve even higher levels of digitalization as Siemens continuously improves and expands its Xcelerator portfolio, which brings together and integrates the entire Siemens Digital Industries Software portfolio with embedded tools and databases connecting current and future information technology, operational technology, and engineering technology environments.

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