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Improving electromechanical design collaboration

Executive summary

Enabling effective collaboration is critical for increasing productivity and delivering a robust design. With modern computer-aided design (CAD) tools and intelligent software, designers are able to synchronize their data more efficiently and collaborate between domains more effectively on critical items, thereby ensuring the design intent is properly implemented. This enables engineers to do what they do best: innovate.

Facilitating cross-domain collaboration spurs innovation

Introduction

Today's demanding customers expect more "intelligence" and functionality in their products, regardless of the industry. Because of this, the use of electronics in traditional mechanical devices is increasing at an unprecedented rate, and all of these electrical signals must be physically connected throughout devices. Sensors are being added to practically everything in an effort to connect devices and create a "smart" world. Signals from sensors are carried via wires to embedded control boxes, actuated components and antennas. Then wires are bundled into harnesses. As a whole, these electrical distribution systems create the nervous system of today's products.

The result is increasingly complex electromechanical systems, in which electronics and software control the mechanical aspects of a design. Unfortunately, complexity is rendering previous best-practice processes ineffective and, ultimately, obsolete, with designers having a hard time keeping up with the fast-changing demand. The days of throwing designs over the wall for implementation, and then waiting for physical prototypes to be built to see if the product works as intended, are gone. Engineers are being asked to work outside their normal domain with mechanical engineers often dealing with electrical requirements, and vice versa.

Unconnected domains lead to challenges

Without a coordinated design flow, integration must rely on the availability of physical hardware, which can occur late in the design cycle. Mistakes made during late phases of development can be costly. When not caught until the prototyping and testing phase of design, the result can be significant delays and additional costs. They can even lead to a product being introduced too late to the market. As complexity continues to increase, previous design processes are no longer viable.

Why?

- When electrical and mechanical engineers work in two different environments, it can be difficult to communicate about the most basic things. Are the two talking about this wire or that wire? The electrical engineer is looking at a line on the diagram. The mechanical engineer is looking at a wire, cable or harness routing in the 3D mechanical assembly. This can introduce significant friction, delays and errors into the process
- In an uncoordinated flow, electrical engineers provide the complete diagram, bill-of-materials (BOM) and drawings to the mechanical engineer, who must interpret these deliverables to figure out what wires need to be routed between components. This manual process is prone to human error

Figure 1: The traditional separation of electrical and mechanical engineers inhibits synchronizing the design.

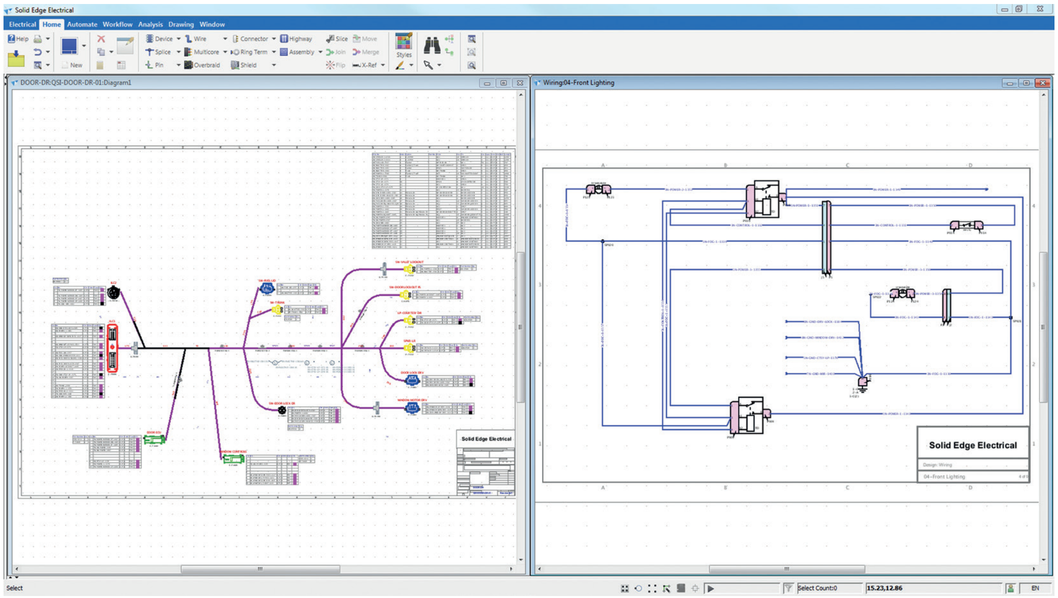

Figure 2: The common misconception of the simplicity of wire harness manufacturing.

- Electrical systems design is rarely completed in one pass. Instead, it is often an iterative process between the electrical and mechanical engineer. Every time there is such an iteration, each engineer must reinterpret modifications. This introduces even more opportunity for human error

These shortcomings result in errors that proceed downstream, where they manifest in issues that cause several rounds of prototyping and testing. So the assumption that isolated departments of design can still work effectively is no longer valid. Electrical and mechanical design can no longer be islands of isolation.

Impediments to ECAD-MCAD collaboration

Unfortunately, facilitating collaboration between the people who are executing electrical computer-aided design/mechanical computer-aided design (ECAD-MCAD) is easier said than done. The potential impediments are numerous. Foremost is the traditional separation between the electrical and mechanical disciplines. Electrical and mechanical engineers typically work with completely different tool sets and vocabularies. Many times they even reside in separate physical locations. Furthermore, mechanical and electrical CAD systems have different ways of presenting the structure of the same object.

In an MCAD system, a computer module might be represented in a physical BOM such as the screws, casing, circuit board and connectors. However, an ECAD representation of the same module displays a functional or schematic view that transcends the physical structure of the object. Certain electrical functions might be mapped to several circuit boards and connectors, making it impractical to associate a single function to a single physical part.

When designing the electrical aspect of a system, the right components must be selected, including connectors, terminals, shielding, wire material, etc. There's plenty of electrical design to ensure the system achieves its required functionality. There is, however, a significant amount of mechanical design in the development of electrical systems, too. The electrical connections have to be carefully routed through the physical product and past electronics emitting electromagnetic interference (EMI). This needs to be done so there are no clashes with components, lengths are correct (respecting the physical reality of bend radii) and other considerations are taken into account, such as retention points are located correctly.

As a result, there are many iterations between electrical and mechanical engineers to develop a good electrical system. They need to share detailed design information with each other, which requires close communication and collaboration between them.

However, previous efforts to collaborate have met with limited success. Earlier, ECAD-MCAD collaboration tools used everything from sticky notes and email to Excel®

spreadsheet software. These approaches fell far short for obvious reasons.

Electrical systems developed with a combination of a general purpose diagram tool, spreadsheets and 2D CAD can be used to design and develop an electrical system, but there are several risks:

- The items designed in each of these tools are completely disconnected from one another. That means someone could change the diagram, and if that modification is missed, the drawing and BOM won't reflect the change
- Because the items in the diagram, BOM and drawing are nothing more than lines on a drawing, there is no ability to perform simulations to check their functionality. Design a fuse to accommodate too little current and engineers won't know their fuse will blow until they physically test the design
- Because there is no intelligence in these artifacts, there is no automation in the handoff from electrical design to routing the system through the mechanical product. Mechanical engineers have to manually review the electrical design to determine which harnesses to route and where they should be placed

Fortunately, new design automation processes exist that address these challenges. Intelligent ECAD-MCAD processes provide collaboration between engineers working in electrical and mechanical domains. Simulation allows electrical behavior and performance to be forecast in order to optimize and prove a design, and seamless cross probing between applications enables closer integration.

A new approach to ECAD-MCAD collaboration

It's clear that developing modern electromechanical systems is not an easy or simple task. Instead, it's a highly constrained and iterative process. Companies need new, automated and intelligent solutions that enable true collaboration. Yet in too many development projects today, connected and integrated design is viewed as a luxury. The question should be: How much does it cost to have a product miss its market window?

Electrical quality can have a huge impact on the success or failure of a product, and simulation and analysis play a key role in the early validation of the electrical system. Electrical simulation during the initial design phase can reveal problems that may require a fundamental rethink of the entire electrical architecture.

The electrical system is strongly interlinked with the physical design so changes in the electrical system may require changes in the mechanical packaging, too. These kinds of architectural changes – whether electrical or mechanical – are easier and cheaper to make in the early design phase of a product.

Adding new intelligent software to the design process gives the engineer data about the device being designed. This data can be used for simulation and analysis purposes, which are cornerstones of a connected and integrated electromechanical design flow.

Simulation also reduces the need for physical prototyping, cutting both time and cost from a program. Computer-based methods for simulating and evaluating electrical designs represent a major step forward in validating design integrity – far beyond what can be achieved using physical prototypes.

A typical intelligent design workflow

An electrical designer publishes a BOM for the electrical system, which can then be integrated into a robust 3D CAD environment, such as Siemens PLM Software's Solid Edge® software. With this integration, the electrical system can be designed with explicit knowledge of potential wet, hot and other exclusion zones in the mechanical design. Doing so allows the electrical design engineer to take into account mechanical constraints when designing the electrical system. On the mechanical side, space reservations can be made and the severity of bends in the harness can be adjusted to account for the wiring bundles that must route through the mechanical structures. With access to this contextual information from other domains, both electrical and mechanical engineers are able to quickly reconcile incompatibilities between the electrical and mechanical designs.

The mechanical engineer wants to make sure the bundle containing all of the necessary wires will route through the allotted physical space. But the mechanical engineer does not want to create and manage these wires in the MCAD model; it would be too difficult and time-consuming. Instead, the electrical definition is created in software such as Solid Edge Wiring and Harness Design. The maximum allowed bundle diameter, based on various mechanical constraints, can be sent to the Solid Edge module, which will confirm that synthesized or routed wires in these bundles do not exceed this maximum allowable diameter. This can be done by using the automatic design rule checks functionality in Solid Edge Wiring and Harness Design.

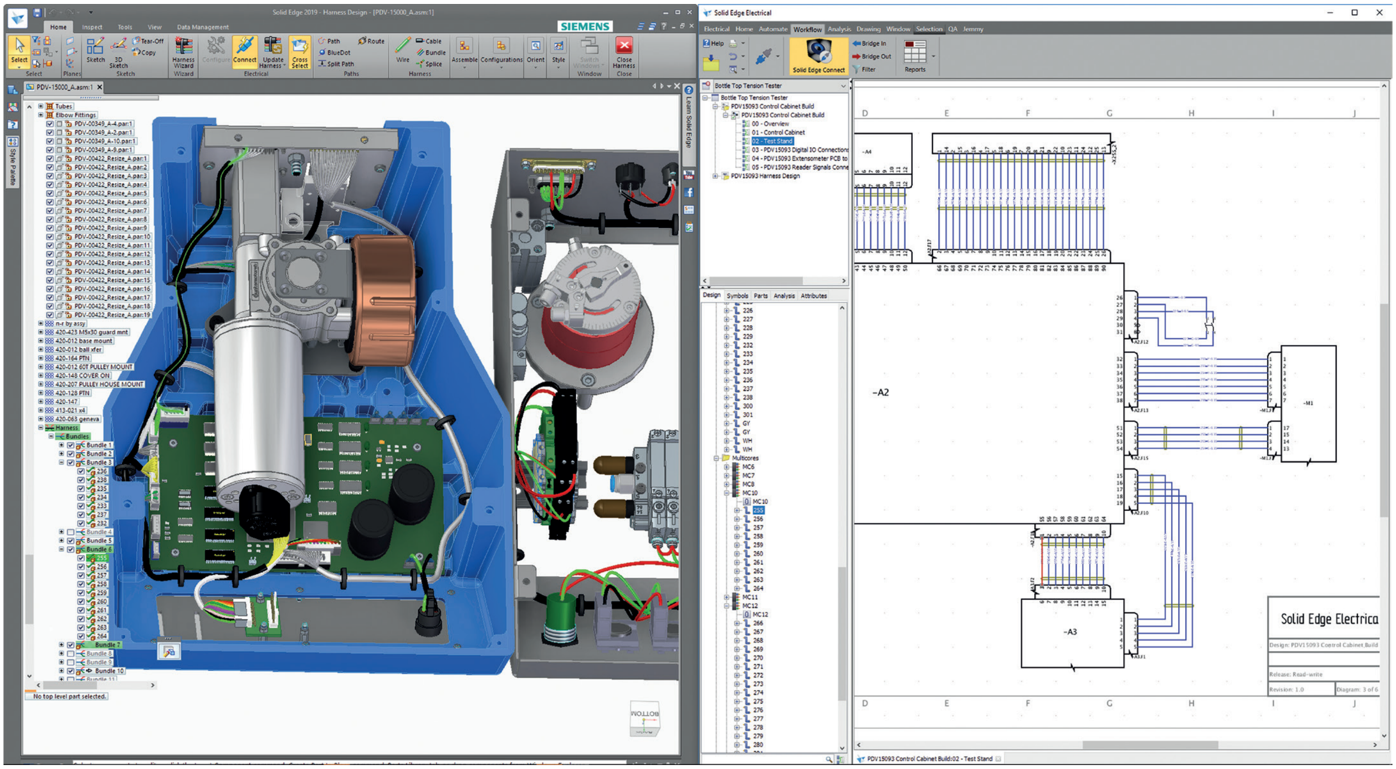

Figure 3: Cross-probing capabilities in Solid Edge Wiring and Harness Design.

Furthermore, the addition of objects like clips, grommets and tubing to the harness design requires cross-domain collaboration. These objects are best created in a 3D MCAD environment and then merged with electrical data from the ECAD tool. Once this association is made, the fully buildable wiring harness can be automatically engineered and fully configured.

At the end of this collaborative process, each engineer knows that his/her part of the design works in the context of the entire system.

Adding intelligence to the electromechanical design process

Solid Edge electrical design software is designed to specifically meet the needs of midmarket customers, for whom considerations such as ease of implementation and low total cost of ownership (TCO) are paramount. This design software goes beyond traditional capabilities in this market, bringing in sophisticated, high-end functionality, such as advanced simulation of voltage and currents, and highlighting problem areas such as short circuits and validating fuse sizing. By coupling this functionality with its highly automated harness design and documentation capabilities, Solid Edge Wiring and Harness Design enables customers who have not typically been able to access such tools to enjoy greater success and outpace their larger competitors.

When used with Solid Edge 3D CAD, Solid Edge Wiring and Harness Design offers capabilities with significant advantages for the collaboration between electrical and mechanical engineers, including:

- Providing a complete set of information about the electrical system to Solid Edge 3D CAD. This means the mechanical engineer receives a list of components to place and electrical connections to route. Furthermore, because Solid Edge knows which and how components are connected, it can automatically route the wire, cable or harness, eliminating human error from 3D routing
- Communicating changes back and forth seamlessly. Cross probing and cross visualization between environments enable designers to understand signal routing in the 3D space, so they can determine optimal routing to avoid electromagnetic and radio interference. One engineer simply has to push his or her modifications to the other and they show up in

the design. This further eliminates human error in the design process

- Offering interactive highlighting. When an electrical engineer selects a wire in the diagram, the corresponding wire in the 3D mechanical assembly is highlighted. It works in reverse, too, with the wire in the diagram highlighted when the corresponding wire in the 3D mechanical assembly is selected. This enables more accurate discussions about identifying and resolving issues across engineering domains
- Adding intelligent diagrams, BOMs or drawings, knowing that each of these representations are part of the same component, connector or wire. A change in any of these places shows up everywhere, eliminating the potential for errors because a change wasn't manually updated
- Enabling electrical engineers to simulate systems and run analyses to verify that everything works as expected. They'll catch the state of the electrical system that results in a blown fuse long before prototyping and testing
- Enabling the design information to be handed off as a set, providing a to-do list for the mechanical engineer routing the system through the product

Using Solid Edge Wiring and Harness Design helps resolve the challenges of electromechanical design. Supported by industry-leading electrical software from Mentor Graphics, now part of Siemens PLM Software, the tightly integrated solution enables co-design across domains. And coming from a single vendor, Solid Edge Wiring and Harness Design provides an intimate integration that is not possible with third-party and private-labelled add-ons. When used with Solid Edge 3D CAD, the capabilities of Solid Edge Wiring and Harness Design allow companies to design and develop electromechanical systems quicker and more cost effectively.

Conclusion

In most products on the market today, especially in smart connected products, electrical systems are crucial. They supply the correct power for electronic devices, and enable multiple, interconnected systems to communicate efficiently and accurately. Today's products aren't functional without good electrical systems.

Electrical design is strongly interlinked with the physical packaging and attributes – the resistance of a wire is dependent on its resistivity and length. In the early days of electrical design and analysis, the definition of wire lengths, for example, was an intensely manual process. But as electrical designs became more complex, the manual approach became impractical, and tight integration between the electrical and physical design was developed to address the requirement to have consistent and coherent models between the domains. This integration is achieved by creating a roundtrip interface between the ECAD and MCAD tools, in which the ECAD tool contributes the connectivity information for each wire, along with other important attributes. The MCAD tool then routes the wire, cable or harness through the 3D physical space, and sends the wire lengths back to the ECAD tool. This collaborative process enables faster design.

Collaboration has long been recognized as a potential enabler for increasing productivity and ensuring a robust design. With modern CAD tools and intelligent software, designers are able to synchronize their data more efficiently and collaborate between domains more effectively on critical design items, thereby ensuring the design intent is properly implemented and can achieve first-pass success.

A tightly integrated electromechanical solution, such as Solid Edge Wiring and Harness Design, enables collaboration across domains, freeing engineers from having to attend meetings to discuss changes introduced by manual errors. Using an intelligent design methodology, the impact of a change in both domains can be assessed in a collaborative environment, allowing engineers to do what they do best: innovate.

As a tool that provides simulation, a direct connection between multidisciplinary domains and cross-probing functionality, Solid Edge Wiring and Harness Design liberates engineers from the drudgery of manual tasks, enabling them to spend more time creating great products.

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