Product-level architectural validation is the missing link of design flow

Bob Potock - December 16, 2015

Product-level architectural validation bridges the procedural gap between the marketing requirements definition and detailed design work. During this high-level phase, critical decisions are made that affect the product’s functionality, size, cost, and other key parameters. These decisions include the number and shape of the boards, size and shape of the enclosure, size of the display, number and location of connectors, battery configuration, radio frequency (RF) planning, block reuse, etc.

But the standard authoring tools used today do not support design exploration and productive trade-off discussions required for design optimization. Most design processes leap from marketing requirements to detailed design without architecture validation. Changing key design elements during the detailed design process is expensive and often causes the product to miss its delivery date. The odds of product success can be significantly increased when a multi-domain design team optimizes the product architecture in the early stages of the design process to fully support the product requirements. The architectural validation process is needed to bridge product requirements with detailed design to deliver a cost- and functionality-optimized product.

A new generation of design exploration and validation systems addresses this challenge by enabling key product decisions to be evaluated collaboratively. Contributors can provide ideas and feedback in the early stages of the design process and evaluate the impact of these suggestions on the design. During the architectural validation phase, the logical aspect of the electronic system is defined using functional blocks and schematics. The functional blocks are dragged and dropped on 2D PCBs to create placement plans in order to evaluate alternative design partitions. The fit of the boards and other components is evaluated in a 3D view of the mechanical enclosure. The system tracks parametric values of the components, nets, and other elements in the design, enabling users to optimize part usage, cost, and availability. The design team can explore the design space and make tradeoffs to optimize the form, fit, function, and cost of the product in the early stages of the design process.

Collaboration is key to electronic product success

Today’s electronic products are delivering ever-increasing capabilities in smaller, sleeker packages. With most of the electronic content of products being consolidated into systems-on-chip (SoCs), competitive differences between products often boil down to software, cost, size, style, weight, and battery life. At the same time, miniaturization has reduced the space available in which the electronics reside while higher performance has made the PCB layout even more critical. The net effect of all these trends is that the hardware design has become more standardized but PCB layout
including signal integrity and mechanical integration have become much more challenging, requiring greater collaboration than ever before between design disciplines.

With PCB layout and mechanical integration becoming key to product success, more attention is focused on the critical early stages of the design process where requirements are implemented in practical design decisions. This is the stage where the product is configured and decisions such as how many boards are in the system and what functions are on each board are made. The consolidation of electronic content has narrowed functional differences between products and shifted the focus to a broader mix of competitive factors. The highly competitive nature of today’s market puts a premium on the upfront evaluation of design alternatives while considering their impact on the final product in order to deliver a more competitive product. Today’s typical system-level planning process of typing a bill of materials into a spreadsheet program, ginning up the enclosure in a mechanical computer aided design (MCAD) system, while evaluating PCB placement in a third tool is clumsy, error prone, and limits the number of alternatives that can be considered in a timely manner with an acceptable level of accuracy.

Platform for concept development and design creation

Multi-domain design exploration and architectural validation

(note: All the images in this article can be enlarged by zooming or opening in another tab.)

The new generation of design exploration tools provides a platform for concept and design creation through, for example, logical, 2D physical, 3D geometrical, and parametric views. These four main modules work together or standalone and may appear individually or simultaneously on the screen for real-time interaction with each other. All of the views are integrated so that when the user makes a change in one view, the others automatically update. The user interface is designed to be simple enough for use by both occasional users as well as everyday architects and engineers.
Logical design module

The first step usually involves creation of the functional design using reuse blocks, functional blocks based on a list of components, or any existing detailed design. A common approach is to start with a fully supported previous generation of the product. Many companies are beginning to standardize on a design platform, which may also be used as the starting point. Users can also make use of engineering data management software that manages reusable circuitry in the form of blocks, greatly simplifying the process of reusing existing schematics, parts lists, and layouts. The engineering data management system stores and controls access to reusable blocks, manages information that is critical to design reuse such as the layer structure of a routed block, and interfaces easily with the design exploration tool.

The user working on the new design can easily call up blocks representing the RF, baseband, Wi-Fi, Bluetooth, and other sections of previous designs. The engineer can then check the documentation for each block that he or she plans to use to ensure that it is a fit for the new design. Then the engineer can drop the blocks into the design. Integration with the ECAD library provides accurate floorplanning with exact footprint shapes and automated parts list creation. Design reuse saves time during functional block design and also reduces downstream circuit design effort. Reusing routed PCB blocks offers considerable potential advantages such as avoiding potential signal integrity and thermal problems by utilizing modules whose performance has been proven in previous product generations.

Blocks partitioned onto PCBs
Physical design planning and validation module

The blocks are partitioned onto multiple PCBs by dragging them into the 2D PCB partitioning and floorplanning view. The user can manage multiple boards in one view and arrange the layout of the design as a complete system. Alternative configurations are evaluated by moving blocks between boards, reshaping the boards, and adding/removing PCBs as needed. Top and bottom board density can be calculated as a quick routability check during this phase. The user can select a combination of PCBs, packages, and SoCs comprising one design and complete its layout as a full system. Signals can be highlighted and analyzed across the entire interconnect length.

3D geometrical design and validation module

Users can import the mechanical enclosure directly into the geometrical module to verify the fit of the boards. Bidirectional exchange of STEP and IDF data with 3D MCAD systems makes it possible to share enclosures, PCBs, and complete system assemblies. The integration with the ECAD library provides accurate floorplanning with exact footprint shapes and part creation. By importing accurate
3D enclosure and component models, engineers can design to the actual 3D enclosure and conduct interference checks to reduce data exchange iterations and optimize multi-board floor-planning and design. Users floor-plan the PCBs within the enclosure in real-time, optimizing placement capacity and capturing interference violations earlier in the design process. Design teams can optimize multiple boards within a single model to ensure precise positioning of PCBs and other components to avoid interference and to mate connectors.

The design team can visualize the mechanical design from any perspective or scale and can generate an STL file so that components can be produced on a 3D printer for even deeper evaluation. Thus at an early stage, the product team can touch and feel the product to determine, for example, whether connectors and buttons are in the right places.

Within an environment that links the logical design, 2D physical design, and 3D enclosure geometry, the design team is able to evaluate a wide range of alternatives. At the same time, the team can track the product cost, weight, number of various components, nets, and other elements in the design, which are automatically updated as the design evolves. For example, engineers can select an enclosure and logical design and compare a one-board configuration vs. a main board and plug-in board configuration. They can evaluate design alternatives by considering the routability of each board, the fit of the boards within the enclosure, placement of connectors, battery location, etc.

**Evaluating design alternatives**

The design team can use each of the analysis views – logical, physical, geometric, and parametric – to evaluate potential design alternatives much more deeply than can be accomplished using traditional methods. In the early stages of the design process, they can consider a wide range of alternatives and reduce the size and or number of PCBs by optimizing floor plans and partitioning between PCBs in the system. 3D spacing requirements can be evaluated in the early stage with interference checks and measurement tools. With these capabilities, the design team can quickly...
create new design variations to determine whether or not a design is scalable across a price/functionality range within a given market, potentially increasing the design ROI.

The integration of the logical, physical, geometric, and parametric elements keeps everyone involved in the design process on the same page. Notes and attributes can also be added to the design at this stage for use during detailed design. After the design plan is validated and approved, the information is transferred to the detailed design suite including schematic capture, PCB layout, and manufacturing tools. The detailed design process is streamlined because key decisions have not only been made but also validated against the 2D physical design and 3D geometry to ensure they will work in the real world.

**Build a more competitive product**

The input to the design exploration and architectural validation process is the product marketing requirements. The new generation of product-level design environments provides a starting point by combining logical, physical, geometric, and parametric design into a single view. This approach enables a design team to quickly explore the design space while considering the effects of alternate approaches on functionality, price, performance, size, weight, and style. Skipping this validation phase could lead to architectural flaws that aren’t discovered during detailed design and which could be of significant impact or even unrecoverable. Utilizing an architectural validation process makes it possible to identify and address such issues prior to the detailed design phase and ultimately results in a more competitive and successful product.

**Also see:**

- ECAD & System-level design now "going steady"
- Design shifts from PCB- to product-centric

*The author is with Zuken Inc., which supplied the images.*