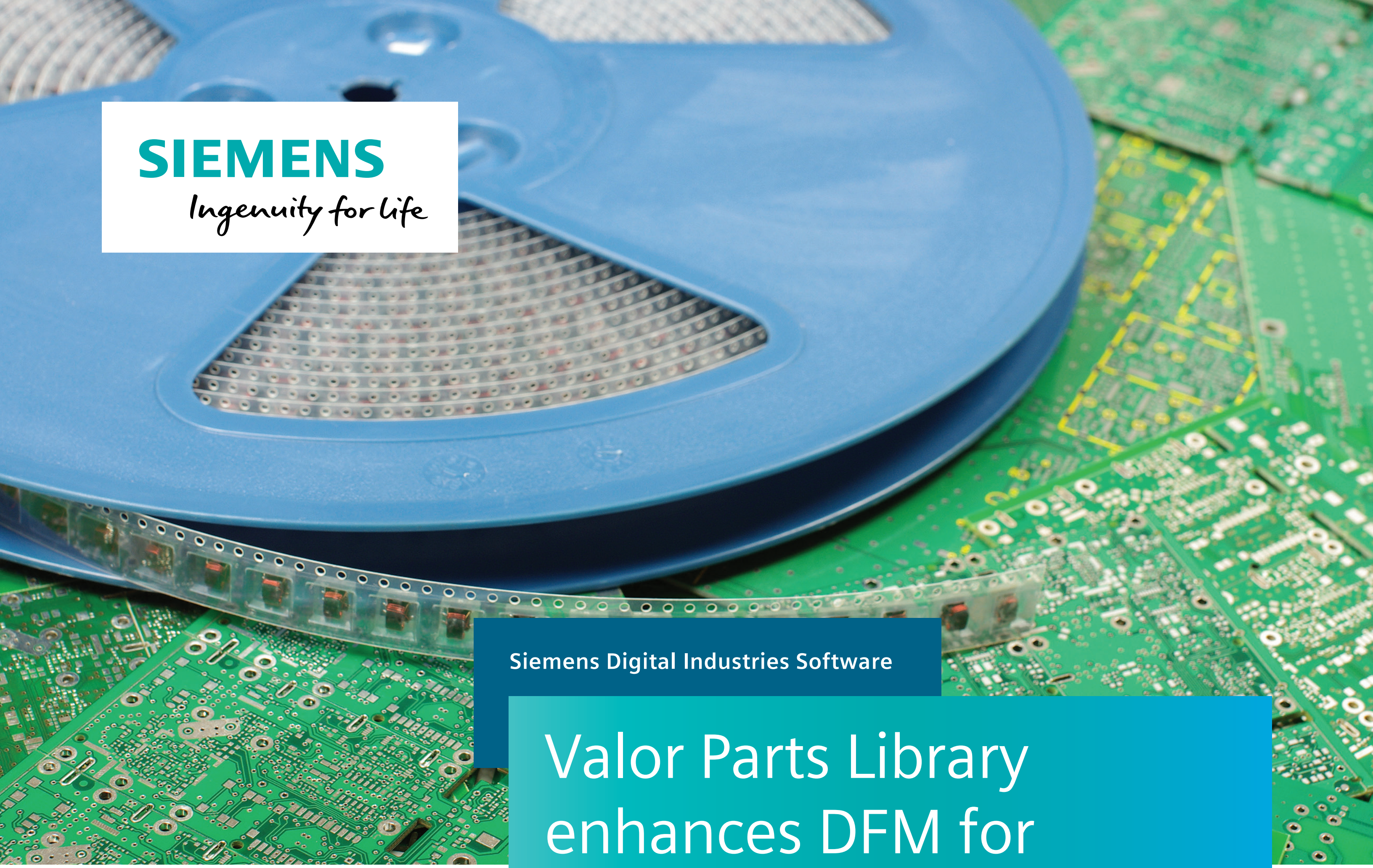


Siemens Digital Industries Software

Valor Parts Library enhances DFM for designing better quality PCBs

Using VPL can avert respins in manufacturing caused by component placement and soldering issues

Executive summary
One frustration that most PCB designers have experienced is a callback from the assembly house requiring a redesign to fit an alternate part or an inaccessible test point. The solution to these issues is a library so extensive that alternate parts could be analyzed and any differences would be flagged. Virtual models would allow proper test point placement. That library is the Valor Parts Library, or VPL.

Guy Shoshany
Product Marketing Manager VPL

Introduction

The electronic industry faces many challenges in the design-to-manufacturing flow. Products continually become smaller, meaning more components on a smaller PCB. Products are also designed, manufactured and delivered at an ever-faster pace. Room for errors in the design-to-manufacturing flow becomes increasingly small.

The Valor® Parts Library (VPL) is a unique tool that can help to overcome these challenges. It provides accurate physical models of electronic components and connectors used in PCB manufacturing, test and assembly, delivered in a consistent, EDA-friendly interface. The accurate physical representation of the component's package, along with other data stored in VPL, when coupled with design for manufacturing (DFM) checks, allows designers to detect errors during layout that will cause problems in manufacturing. This saves considerable time and cost by avoiding respins to address those problems.

VPL enhances your existing PCB design library with robust data suitable for DFM

Even the highest-quality PCB design libraries contain only a fraction of the data available in the VPL. The VPL library consists of more than one billion electronic component manufacturers' part numbers. The VPL library contains accurate component geometries, referred to as packages, and part attributes such as height, pitch, length and width. Package names comply with JEDEC JES-D 30I standards.

Employing assembly-level DFM checks allows potential manufacturability issues to be identified during PCB design before releasing data to manufacturing. However, this assembly-level DFM is only as good as the quality and content of the component representation used. The VPL provides a high-quality and reliable representation of a component package for use during assembly-level DFM analysis, as illustrated in figure 1.

Industry challenges

- Each product development project becomes more and more complicated and requires an involvement of several contributors: product managers, designers, fabricators, procurement, assembly managers, delivery, etc. Each has their own say and may influence aspects of the project
- Fabrication and assembly issues may cause product changes. The product can go back and forth between design and assembly for respins until the required result is achieved.
- Respins can delay product delivery and result in missing the time-to-market requirements.
- Respins tax available resources such as work hours, machine wear and tear, electricity, etc.
- Tighter component-to-component spacing in each board complicates assembly.
- A wide range of component package sizes are used that include both SMT and through-hole technologies.

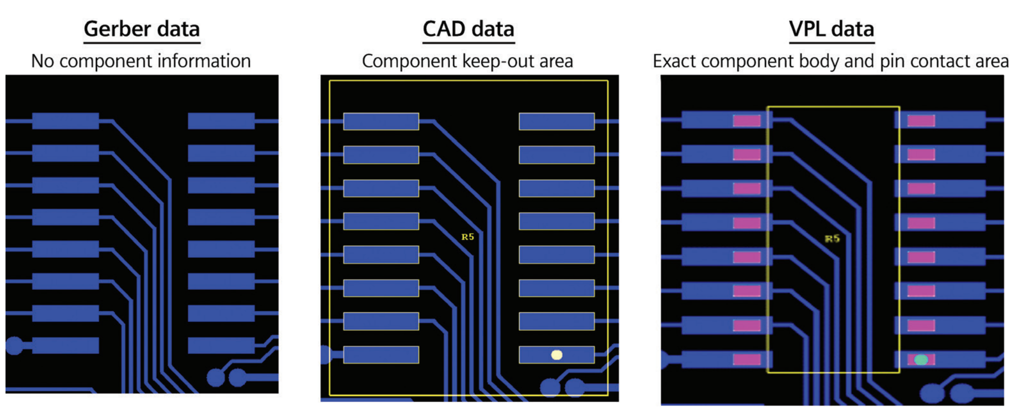


Figure 1: Comparison between a board with only Gerber data, CAD data and VPL data.

For example, only with VPL can DFM be intelligent enough to analyze a design and locate soldering issues with components, which could result in a costly respin. The soldering analysis allows you to identify potential footprint issues that affect the quality of the solder joint or the yield at test.

Best practices for using VPL for DFM

Creating the best design with highest quality requires a robust component library in addition to requiring expert data about the fabrication and assembly process. In a typical new product introduction (NPI) flow, the parts are selected and the schematic is created. Parts placement, followed by layout, creates the design. Then the design data is packaged and passed to the fabricator to build the bare board. While DFM is performed by the fabricator, they are not validating for assembly related issues. This results in costs incurred and time consumed before the assembly service provider even sees the data.

Once the assembler receives the design, they run DFM based on their assembly capabilities. This often results in finding issues that may be corrected by a respin of the design. However, solderability issues may not be located until much later as use of alternate components may not have been taken into consideration.

In the worst case, these manufacturability issues can result in missing the project deadline and exceeding the project budget. By missing the targets, revenue targets usually suffer.

As board density increases, margins for error decrease and the ability to detect errors manually becomes nearly impossible. Different mounting technologies also introduce the chance for design issues. That adds up to an absolute requirement for the level of detail provided in VPL.

Component data in VPL

A rich set of data resides in VPL to allow accurate DFM analysis. That data includes:

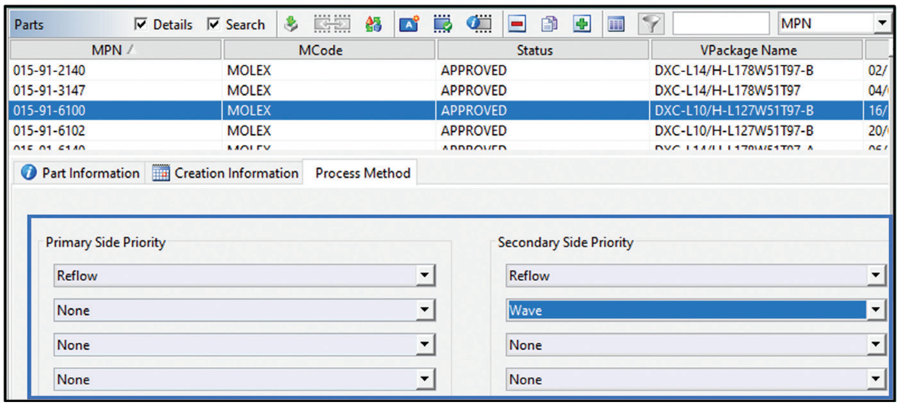
- **Manufacturer part number –** Manufacturing part number is a unique identifier for each component; it is assigned by the manufacturer.
- **Vendor code –** This is a unique identifier assigned by the VPL team for each of the listed manufacturers in the database.
- **VPKG (VPL package) –** VPKG provides a unique code that represents the component's physical appearance, sizes and attributes. The VPKG is used by Valor NPI for DFM analysis.
- **Other data:**
  - Material
  - Component functionality
  - Link to the component's manufacturer's datasheet
  - Component image
  - Manufacturing
  - Package body data
  - Lead data

Sidebar 2 summarizes the details that are contained for each VPL part number and related package.

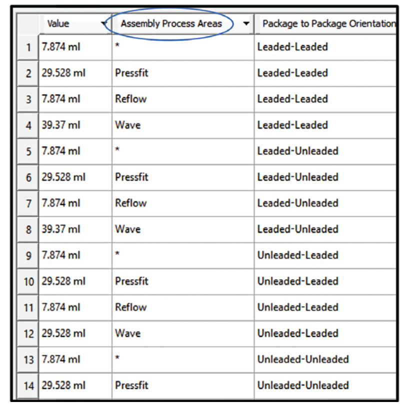
Based on VPL capabilities when used with Valor NPI for DFM, a set of best practice procedures has been developed. Here are those best practices and how they can be employed to improve product quality and reduce respins of the design.

Component spacing

VPL



Valor NPI



	Value	Assembly Process Areas	Package to Package Orientation
1	7.874 ml	*	Leaded-Leaded
2	29.528 ml	Pressfit	Leaded-Leaded
3	7.874 ml	Reflow	Leaded-Leaded
4	39.37 ml	Wave	Leaded-Leaded
5	7.874 ml	*	Leaded-Unleaded
6	29.528 ml	Pressfit	Leaded-Unleaded
7	7.874 ml	Reflow	Leaded-Unleaded
8	39.37 ml	Wave	Leaded-Unleaded
9	7.874 ml	*	Unleaded-Leaded
10	29.528 ml	Pressfit	Unleaded-Leaded
11	7.874 ml	Reflow	Unleaded-Leaded
12	29.528 ml	Wave	Unleaded-Leaded
13	7.874 ml	*	Unleaded-Unleaded
14	29.528 ml	Pressfit	Unleaded-Unleaded

Figure 2: Process methods presented on the VPL Library Manager tool (VLM) (left) and the assigned spacing values according to the process method and the package-to-package orientation in Valor NPI (right).

Component spacing rules are essential to allow correct tolerances for assembly equipment. Proper spacing is also important for efficient rework. The VPL determines and contains the primary and secondary side (figure 2 – left) recommended process method for each part. The assembly analysis requirements are later based on the process method assigned to each component by the VPL and the components arrangement, leaded or unleaded, to one another (figure 2 – right).

Figure 3 shows the layout with the components spaced using only CAD package data. It seems that the components fit with adequate space to allow automated placement. However, as shown in figure 4, the VPL package of the alternate part number is wider than the package keep-out used for the CAD data, and now the parts are too close together for the placement equipment. With VPL models (figure 5), the varying size of the alternate parts can be considered during design and issues such as this can be identified and immediately corrected.

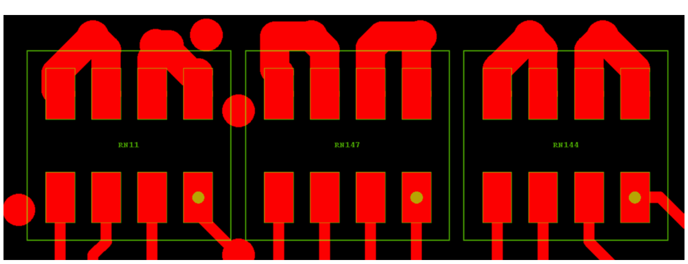


Figure 3: Component spacing using only CAD package data.

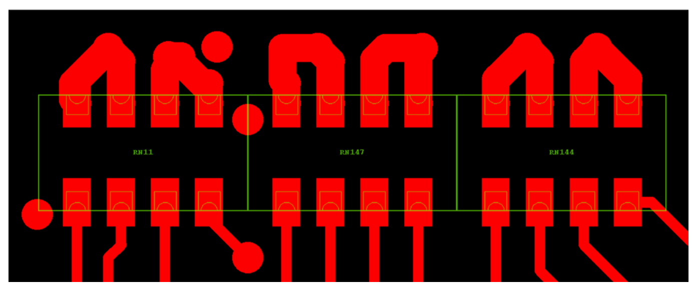


Figure 4: During assembly, an alternate part was chosen that was wider than the part used for layout. The result is that the components interfere with each other.

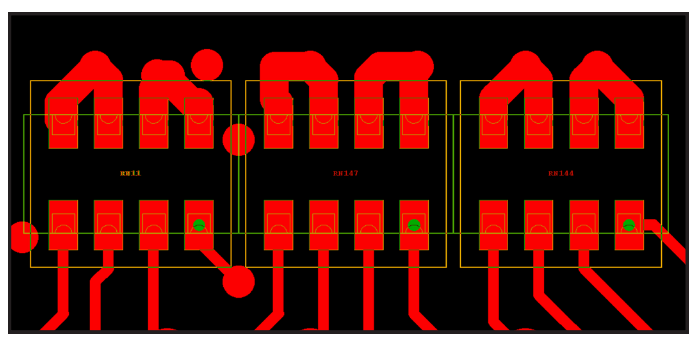


Figure 5: A combination of the CAD packages and the VPL packages shows the difference between the CAD packages spacing (green) and the spacing using VPL packages (orange).

Soldering analysis

Solderability issues can arise from a number of sources during design. In addition to being able to properly solder components, consideration also needs to be taken for possible rework. With VPL, the exact fit of the components on the board footprint can be viewed to create a virtual prototype, as shown in figure 6.

Creating component footprints can be difficult, especially with large ball-grid arrays with hundreds of balls. Valor NPI with VPL identifies potential solderability issues with their component footprints that otherwise could not be determined without having to build physical prototypes. Valor NPI uses the lead contact areas, provided by the VPL, to determine if the minimum requirements are met for proper soldering requirements using toe, heel and side or periphery, depending on the lead requirements (figure 7). Valor NPI employs solder validation as defined by IPC-7351B.

Soldering requirements can be viewed for each type of lead in VPL. Those requirements define the corresponding constraints as shown in figure 8. This data is critical to soldering analysis.

The same analysis can be made for through-hole leads. To achieve proper wave soldering, sufficient spacing is required between the plated-hole wall and the edge of the through-hole lead. Solder validation for through-hole leads is based on the IPC-2221 specifications.

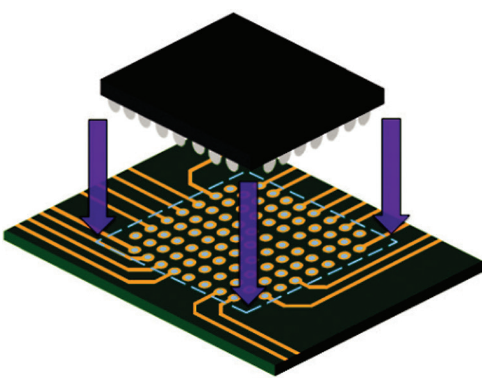


Figure 6: Valor Parts Library shows how components will actually fit on footprints.

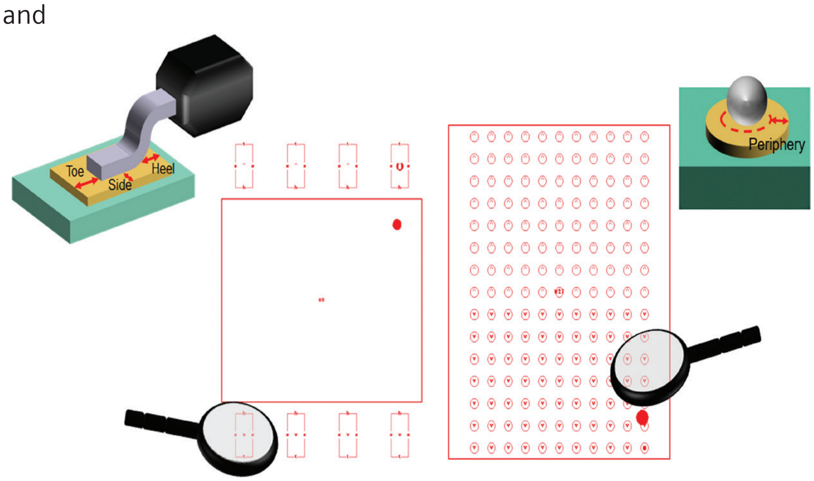


Figure 7: Toe, heel and side filet on SMT lead and periphery on a ball lead.

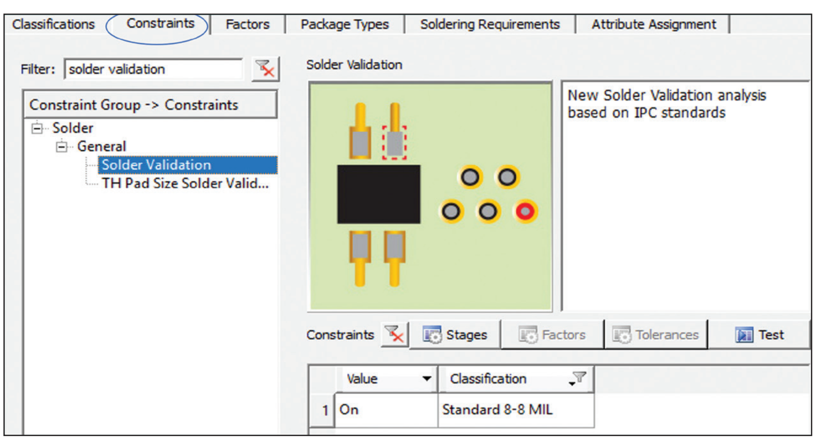


Figure 8: Definition of lead type parameters and spacing requirements become solder validation analysis constraints.

Approved manufacturer list and approved vendor list management

Multiple part sourcing is often a requirement for a new product design. But, will an alternate part fit properly on the board – not just relative to adjacent components, but also an identical footprint? Your component engineering team is tasked with sourcing and qualifying alternate parts, but do not have the tools to make this foolproof. The only way to systematically identify whether any of the alternate parts will present a manufacturing challenge is to run the alternate parts analysis in Valor NPI using VPL content.

The VPL can maintain the relationship of the EDA part numbers to possible manufacturer part numbers. VPL users can obtain a full list of manufacturer part numbers that link to their EDA system's part list and create what is referred to as an approved manufacturer/vendor list (AML/AVL). VPL imports the AML/AVL for reference between component part number (CPN) and manufacturer part number.

Figure 9 illustrates three alternate parts from an AML. The three vary slightly in dimension. VPL can conduct an alternate parts analysis and construct a composite body to be used for assembly-level DFM so that all three alternate parts will fit the designed-in space. Using that composite model and running concurrent DFM guarantees that any of the three part alternatives will fit without causing any manufacturing issues.

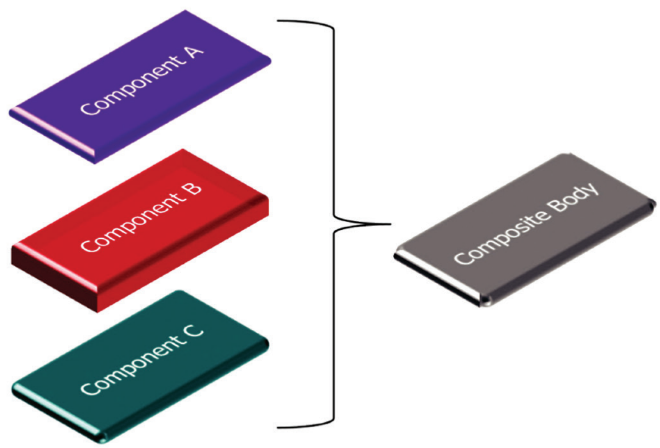


Figure 9: Alternate parts can be different in body and pin contact. Only VPL can tell you if those differences are problematic.

Automated optical inspection shadowing

VPL contains height information so that accurate assembly-level DFM analysis can be performed for issues where height affects the results, e.g., automated optical inspection (AOI) shadowing.

The AOI machine uses a light that shines on the board and is vital to make the optical inspection. Because of this light, tall components can cast a shadow on leads of components that are placed close to the tall components, which can result in incomplete AOI coverage. Figure 10 shows how the shadow cast by a tall component can obscure the toe of a shorter component, preventing proper optical inspection.

Identifying AOI challenges early in the design stage ensures solder joints, which are what makes a board work, can all be validated during assembly, resulting in a quality product. In figure 11, the shadow cast by a tall M1 component obscures vision of pin 1 of the resistor network, and is clearly identified with Valor NPI.

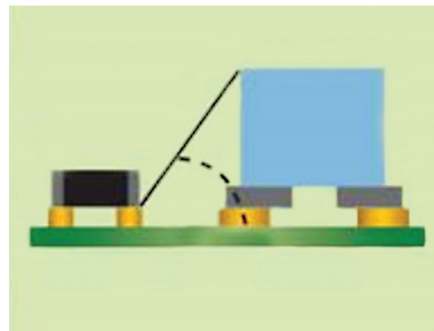


Figure 10: AOI toe print shadowed by component.

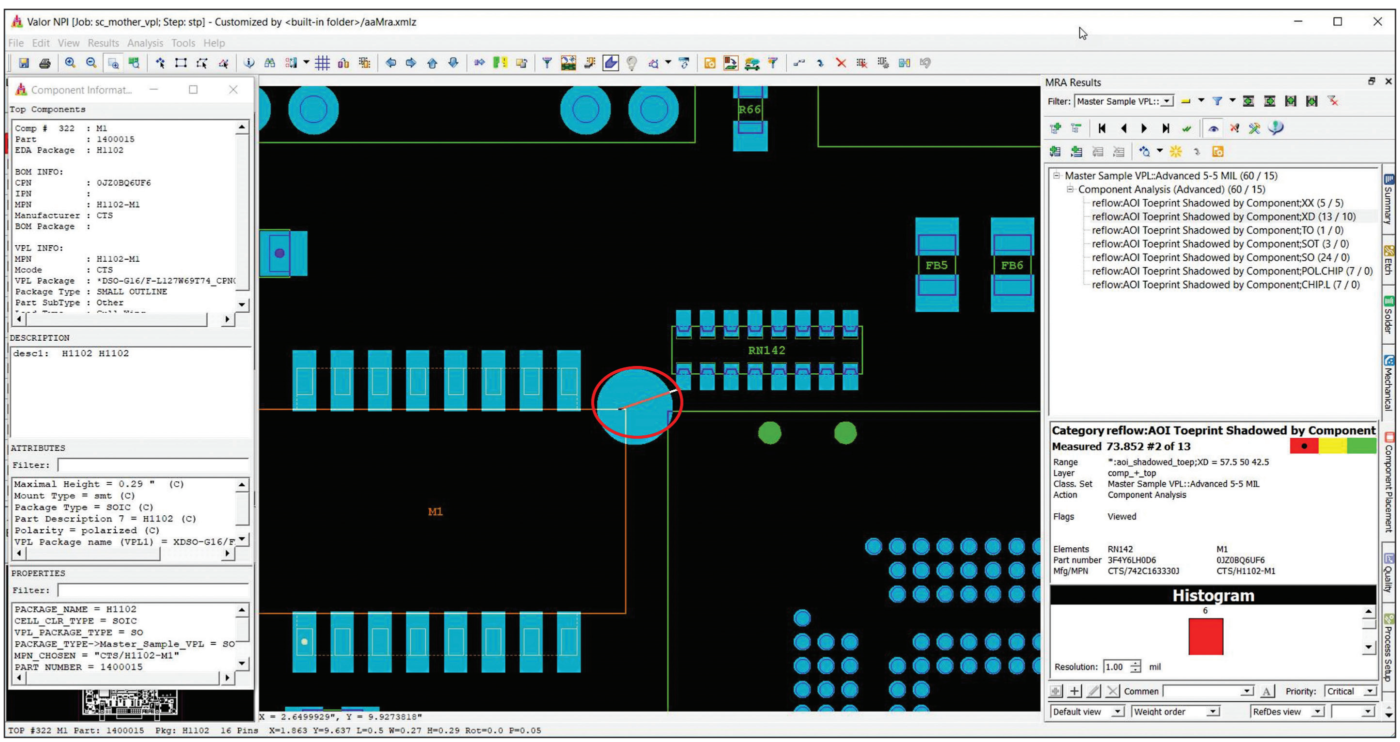


Figure 11: Example of M1 that is 290 mils tall close to a toe print of the resistor network causing a visual shadow.

Test access using flying probe machines

Similar to issues with optical shadowing, an assembled board may also need to have enough spacing to allow for accessing of test points by flying probe machines. These test points are usually located close to component leads. For optimal test results, the machine should be able to access all the test points from all directions. For tall components in higher density boards, the machine may not have a proper access to all the test points.

The VPL stores accurate dimensions of packages, which ensures designers set up the test points and the components such that the flying probe machine can efficiently test all the test points.

Valor NPI uses two methods to check spacing between components and test points. The first is to check the test-point-to-component angle (figure 12) because test probe angles are limited. The angle measured from the top of a neighboring component to the test point location determines if the test point is accessible to the probe.

The second method is component-to-test-point spacing. Test probe access is limited by the proximity of the neighboring components and therefore, the spacing from the probe to the component determines if the test probe can access the test point without being interfered with by a neighboring component.

Rework access

With any manufacturing process, soldering issues may come up during the assembly process requiring the board to go through a rework process. The challenge is to remove the defective component without damaging the other components that are also soldered on the board.

The accurate sizes of the VPL package models help will designers leave enough spacing between component to allow for rework activities and tools, making the rework process easier, faster and more precise – resulting in lower rework cost.

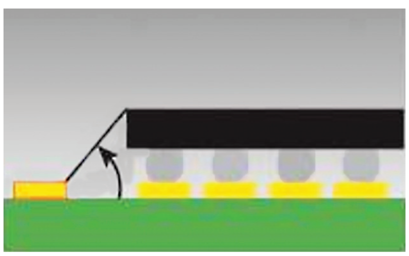


Figure 12: Test-point-to-component-angle.

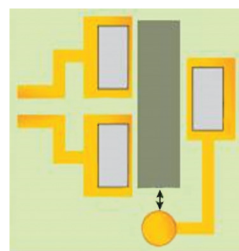


Figure 13: Component-to-test-point spacing.

VPL coverage

Even with billions of manufacturing part numbers in the Valor Parts Library, there will be cases where customers need parts not already in the VPL. To address that need, and for when customers have proprietary parts they need to model, customers can either create their own VPL content to be stored locally or have parts be added at their request using the VPL Content Creation Services.

Conclusion

VPL is a critical component for performing manufacturability analysis that results in better quality PCBs, which can be readily manufactured. No other component library available contains anywhere near the number of parts that have complete geometric representation.

VPL can be used to address many of the industry's challenges, and it is an important tool in the design-to-manufacturing flow. Coupling VPL with Valor NPI DFM software allows you to perform comprehensive manufacturability analysis during all stages of the design to detect errors at the earliest possible stage. Discovering and correcting issues that can potentially exceed the project budget and/or miss schedule deadlines not only saves time and money that would be spent respinning the board, it also allows your company to recognize revenue on the product much earlier.

Siemens Digital Industries Software

Headquarters
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 972 987 3000

Americas
Granite Park One
5800 Granite Parkway
Suite 600
Plano, TX 75024
USA
+1 314 264 8499

Europe
Stephenson House
Sir William Siemens Square
Frimley, Camberley
Surrey, GU16 8QD
+44 (0) 1276 413200

Asia-Pacific
Unit 901-902, 9/F
Tower B, Manulife Financial Centre
223-231 Wai Yip Street, Kwun Tong
Kowloon, Hong Kong
+852 2230 3333

About Siemens Digital Industries Software

Siemens Digital Industries Software is driving transformation to enable a digital enterprise where engineering, manufacturing and electronics design meet tomorrow. Our solutions help companies of all sizes create and leverage digital twins that provide organizations with new insights, opportunities and levels of automation to drive innovation. For more information on Siemens Digital Industries Software products and services, visit siemens.com/software or follow us on LinkedIn, Twitter, Facebook and Instagram. Siemens Digital Industries Software – Where today meets tomorrow.

siemens.com/software

81948-C7 5/20 N