Executive summary

So, you have invented and designed the next hit product, poised to wreak havoc with the competition and ensure continued financial success for the company for a long time into the future. However, the job is not done until the product hits the street. In between design and sales is printed circuit board (PCB) manufacturing and assembly. All critical business metrics, including cost, quality and delivery, are directly affected by the performance at the factory. Today, more than ever, as customer demand patterns become more volatile, performance and productivity is under threat, with rapidly increasing pressure on engineering and materials infrastructures. This paper discusses the eight steps that you need to take to ensure PCB assembly success and the success of the business, as well as how Siemens Valor NPI tools can help you achieve that success.
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Step 1 – Know your products

Before even thinking about anything else, understanding the product accurately and in detail and its requirements is essential. Manufacturing processes need to match product requirements in a way that is efficient and supports quality. The manufacturing product model is one of the most significant uncontrolled variables that directly affects manufacturing. By the time issues are encountered once the manufacturing engineering processes, or even production, has started, it is too late. Costs of re-spinning the design with corrections, or implementation of countermeasures for issues in production, can exceed the cost of the earliest rectification by several orders of magnitude. As well as the direct cost effect, the delay for the new product introduction (NPI) can cause significant follow-on business opportunity losses if new products fail to reach customers on time.

How the Valor NPI solution can help
- The Valor NPI solution provides you with industry-leading design for manufacturing (DFM) tools
- Based on rules derived from actual process capability and configuration, designs can be analyzed in seconds to reveal opportunities for improvements including cost of manufacture, yield, quality and testability
- The Valor Parts Library (VPL) is a web-based resource that contains accurate and detailed parts shape information used by Valor NPI, so that full DFM analysis can be performed based on any potential material choices, even where materials are not yet physically available
- Hundreds of tests for PCB fabrication and assembly are performed, with clear feedback for layout improvements, without the PCB layout design engineer needing any manufacturing expertise
- The Valor NPI software can be used for incoming product data qualification at the start of manufacturing and as a key design review tool during the PCB layout design process. Valor NPI DFM analysis is integrated with the Siemens Xpedition PCB layout design software so that designs can be completed ready for manufacturing directly in a familiar environment
- The ODB++ file format is used to communicate the complete and accurate manufacturing product model without the use of supporting documents. This provides assurance that manufacturing receives all the necessary information and detail needed to produce the product as expected, as the designer intended, without the need for data reconstruction
- The benefits of using the Valor NPI solution include the reduction of lead-time from design to manufacturing, as well as reduced costs of design re-spins, engineering effort and quality problems
Traditionally, the first action taken for the introduction of a new product into manufacturing is to prepare the data for a specified set of manufacturing processes. From the production point of view, however, the preparation and use of several production configurations is needed up-front to meet the requirements of the customer. Shop-floor planning needs to determine production times, rates and quantities for each product, with a choice of capable production processes, to meet delivery requirements. As the number of discrete products increases and tolerance for finished goods stock decreases, whether in the factory warehouse or in the ever shrinking distribution chain, lot sizes have to become smaller with a much higher degree of production interleave than ever before. The inherent complexity of the surface mount technology (SMT) process operation makes meeting these demands extremely difficult.

Enterprise resource planning (ERP), manufacturing execution systems (MES) or generic shop-floor optimization software provides no significant effective support in
finding efficient ways to perform such mixed production. The result is an unavoidable trade-off between the flexibility of higher mix versus productivity in the operation. Shop-floor planning needs to be able to quickly analyze the shop-floor status, consider changing delivery demand and understand SMT process optimization including material setups with product grouping together with actual machine and line optimization. The most common tool used today to achieve this practically, however, is Excel, which can hardly be expected to be able to find the most optimum production plans for SMT.

How the Valor NPI solution can help

• The Valor Production Plan tool has unique capability to optimize both the selection of products to be made, in accordance with delivery demand, together with the optimized grouping of products through SMT processes using common material setup locations, reducing SMT changeover time while preserving machine optimization and line balance

• Valor Production Plan is a finite tool, capable of planning optimization based on live customer requirements, the current production status and knowledge of available materials

• The top-level plan is derived by ERP together with the requirements for each product, which is then broken down for each line and machine

• The Valor Production Plan software can take literally thousands of products over a period of time and perform optimization for the whole shop-floor, against a flexible set of rules which determine planning policy and priorities

• Changes to existing plans can be executed quickly, without waste or loss, with minimal risk

• The benefits of using the Valor Production Plan tool include an immediate increase of operational productivity, with high-mix production achieving levels of efficiency approaching that of high volume. The ability to respond rapidly and precisely to demand changes means that the factory can be flexible without the need to resort to building stock of each of the products or sacrificing performance
Step 3 – Be ready to make anything, anytime, in any quantity

SMT engineers create production-ready machine programs, test and inspection data and visual documentation by converting the manufacturing product model data and a local bill of materials (BOM), which usually comes from the ERP system. This is often required as a first step in electronic manufacturing service (EMS) companies, where an understanding of the cost of production is required, and also where, by the nature of products such as safety critical automotive, physical production qualification is required.

Performing all of the complex process preparation tasks can be difficult, starting with product data qualification and the merge of the BOM data, which often brings up discrepancies that need resolving before any other processes can start. There is the need to understand any new materials being used, finding out what they are, how they are supplied, sizes and shapes etc. The work of SMT assembly has to be split across different machines in a chosen line, which may consist of machines on different software platforms or from different vendors. SMT-related processes have to be set up, such as screen printer and reflow oven. And a similar process has to be done for each of the test processes and for inspection processes whether manual, automated or both. Then finally, there's operator documentation.

Doing this once per product, in an environment where the number of products and the product mix is increasing, is often enough to soak up all the available engineering resource. In this environment, defacto assumptions are inevitable, placing restrictions that limit each product to a specific line configuration. Planning gets few if any choices for which SMT lines can make each product; each will have the same configuration and so no choice in the production rates can be achieved. This leads to a situation where lines frequently build to stock that is not required for delivery, whereas other lines may lay idle while delivery targets for other products are unachievable.

How the Valor NPI solution can help

- Once the complete validation of the manufacturing product model from design is achieved, the Valor Process Preparation tool takes the design data and merges the BOM. With a full graphics interface, and support from the Valor Parts Library (VPL), discrepancies can be quickly identified and resolved to create a single product dataset.

- The Valor Process Preparation tool can be used to create optimized SMT program sets, test programs, inspection data etc., including all necessary manufacturing engineering process steps across multiple equipment vendors.

- Direct outputs to SMT machines, testers and inspection machines can be made without manual data manipulation, using sophisticated automated native program and library generation tools.

- All engineering processes share a common parts-shape data source, linked with the ODB++ product model data and the VPL web-based shape library.

- Simulation of the SMT machine operation is performed in software, correcting placement rotation and offset errors, removing the need for physical product qualification, and thus avoiding line down-time for NPI qualification.
• The SMT programming team can now respond to the needs of planning and provide multiple capable line configurations for each product to achieve the needed production rates that match delivery demand because alternate configurations for the product can be prepared in just a couple of minutes.

• The benefits from the use of the Valor Process Preparation software include reduced lead time for NPI, increased asset utilization, the elimination of line downtime for product qualification, and the reduction of engineering effort of duplicate maintenance of data in different systems, as well as a general increase in performance of machine optimization, line balance, test coverage, reliability and yield and assembly operation.
Step 4 – Know exactly what you are doing at any time

SMT machines have been developed to be fast, and SMT materials have become so small that it is impossible to follow the operation of SMT machines with the naked eye. Multiply this by the number of machines across all of the lines on the shop-floor, and even the most experienced industrial engineer will be at a loss to explain sudden drops in performance or to find the cause of sudden quality issues. This not only affects the reliability of on-time delivery of products, but also stresses the associated production resources and materials supply because they cannot be synchronized effectively with what is required. Planning changes that may be needed are risky to execute because physical commitment to products partially built, materials consumed and spoilage are unknown. The true utilization of machines is also unknown because recent machines with multiple heads, conveyors and modular stages can hide significant avoidable idle time. The timing of changeovers between products cannot be predicted accurately, which creates operator resource bottlenecks. Reports created using data extracted from individual machines have little meaning because they do not consider their environment, specifically the effects of external causes of stoppages. There is no way of getting data, and the meaning of data differs between machine platforms, with no commonality between machine vendors.

The situation is so poor that manual data collection or simple board counting is still often adopted. Data from the SMT production area generally has minimal value, is inaccurate, incomplete, unqualified and available too late to provide significant value, which is a huge limitation for successful productivity improvement initiatives, planning optimization, material delivery and resource management.

How the Valor NPI solution can help

- No matter what type or vendor of SMT machine or related process, including manual operations, the Valor solution has an interface to read all available data in real-time
- Events and supporting data are read and normalized within the Valor software, so that differences in the data format and meaning are all eliminated and a single common language is created
- Data collected is automatically qualified; for example, when a machine stops, the Valor tool will examine the line to see why the flow of PCBs has stopped, or why the output conveyor is blocked. In this way, the occurrence and cost of any event on production can be accurately attributed
- Information about complex SMT processes is recorded; for example, the under-utilization of modules or heads within complex machines, which exposes productivity enhancement opportunity
- Event data collected includes the precise usage and spoilage of materials so that accurate material consumption can be reported
- As data is collected and processed live, in real-time, it can be used by many of the key operational and control functions that the Valor solution offers, such as Valor Asset Management to increase productivity, Valor Material Management for JIT delivery of materials to the line, and Valor Production Plan to decide planning changes based on the exact current production commitment
- The benefits of using the Valor Production Plan software include an increase in productivity, improved reliability for on-time delivery, reduced on-site finished goods storage and better planning change execution that follows customer requirements
Step 5 – Stay on top of materials

Costs related to excess raw material stock holding in the factory can rival labor cost differentials of manufacturing in different locations across the world. Unexpected issues with materials shortages on SMT machines have progressively advanced the issue of materials from the warehouse to the shop-floor. This results in a reduced incidence of shop-floor shortages, but actually has simply shifted the internal shortages issue itself into the warehouse. As a result of shortages in the warehouse, manufacturing resource planning (MRP) minimum stock thresholds are increased to ensure that there is enough stock on hand to cover the lead time to re-order what has been found to have been lost between physical stock checks. The periodic counting of all materials across the whole factory as a physical stock check has become essential because significant discrepancies accumulate between ERP stock records and the physical raw materials stock on site.

Material logistics effort has also spiraled out of all proportion as materials become un-managed on the shop-floor, lost or spoiled, which comprises over-supplied materials from the warehouse as well as partially used material reels at the end of work-orders. Requirements to maintain control of SMT-specific issues such as progressive moisture contamination are compromised, thus leading to quality issues. Any planning changes suggested for meeting changing delivery requirements from the customers are seen as impossible to execute because of the high risk associated with the unknown physical material availabilities, plus the heavy work-load needed to remove and reallocate kits of materials prepared well in advance.

How the Valor NPI solution can help
• The Valor solution uniquely identifies all materials in the PCB assembly factory, using barcode labels applied to each reel or other material carrier
• Each material has attributes assigned that allow advanced stock management and tracking, including
support for SMT-specific issues such as the baking and dry storage of moisture sensitive materials
• Using mobile terminals and a central material logistics engine, the Valor software provides lean material management, including kanban control between multiple warehouses, to managed locations on the shop-floor, as well as JIT delivery of materials directly to points of consumption
• Material selection from the warehouse is optimized for FIFO and many other configurable rules to reduce obsolescence, reduce searching effort, improve location management efficiency, eliminate stock pick mistakes and to provide specialist controls such as LED bin control
• Materials are verified to positions on machines at the time of setup to prevent machine execution with an incorrectly located material
• Accurate live materials consumption information is synchronized with ERP for MRP to adjust re-order quantities, which ensures ERP raw material data inventory integrity
• The benefits of using the Valor Materials Management software include the elimination of the need for the physical stock check; elimination of setup errors of materials on machines, reducing re-work and quality issues; the reduction of material stock both on the shop-floor and in warehouses; and increased productivity and flexibility to execute planning changes
Step 6 – Exception management

Successful manufacturing can be thought of as the creation of perfect products, one after another. Variation in many different areas that affect the quality of the products threatens that perfection. The whole regime of test and analysis of products has been developed because of defects found in products as a result of production processes gradually or suddenly going out of control. For example, a change in the material supplier, although qualified to supply under a common internal part number, can cause a sudden increased incidence of placement errors if there is just a small difference in height. Machine visual detection algorithms can often find these changes, which can be good for reducing placement errors, but this increases the “invisible” spoilage of materials at the machine.

Many other issues will pass through only to be discovered at test. As well as material-related issues, process issues at screen printing, SMT mounting accuracy and reflow all exhibit variation to a degree. The obvious need is for the test process to act as a filter, ensuring that no defective products make it out of the factory and into the market. However, the nature of test means that this can never be guaranteed. Statistically, the greater the defect rate found inside the production operation, the greater the corresponding defect rate in the market.

With Internet shopping sites hosting customer product reviews and the abundance of social media, this means that the effect of any defect in business terms can be magnified greatly out of proportion. A key factor in reducing defects through test and repair is the speed of response to find out the cause of an error and the scope of those products potentially affected. Timeliness and accuracy are critical. Any delay between the defect being created and being detected increases the quantity of potentially defective units. The effective delay is contributed to by the time taken to get the unit in to test, recognize that a defect has been found, qualify that defect, record it and correctly route the defective unit to a repair station, have a repair operator find the repair ticket, search for the defect, understand the cause, take corrective action and finally report it. Because of the severity of potential consequences, if a significant defect has been found, the line is immediately stopped pending investigation, such is the relative potential cost of poor quality versus production.

How the Valor NPI solution can help

• The Valor Quality software captures test results and repair tickets electronically, assigning the results to each specific uniquely identified production unit. This creates an immediate flag which ensures that the correct routing of the defective unit is made to the repair station. At the same time, statistical analysis is performed to determine whether an “out of control” situation has occurred, triggered by the occurrence of this defect.

• The Valor Repair Station solution displays the electronic repair ticket with the manufacturing and test history and the product design layout data to aid and speed up the discovery of the defect. The Valor repair station tool offers a statistically based expert system engine to speed up the link between the symptom of the defect on the repair ticket and the diagnosis of root causes of defects based on past repairs.

• The benefits of using the Valor Quality software include the reduction of time taken for defects to be found and processed, limiting the scope of any quality issue; the statistical identification and alert for out of control conditions; the reduced dependence on specialist skills for defect and root cause analysis; increased timeliness and accuracy of quality reporting which enables changes to assembly operations to reduce the occurrence of defects. With reduced defects in the factory operation, fewer defects escape into the market.
Step 7– Assurance, conformance and compliance

There are high potential costs associated with finding quality issues in the market, especially for products that have a safety or business critical element, such as automotive, aerospace, medical etc. Two key requirements are frequently placed on the manufacturing operation, which recently have even extended down to high volume consumer items, where brand image could easily be damaged.

The first requirement is traceability. Should a defect be found in the market, it is necessary to quickly analyze the source of the defect to determine whether and which other units of the same product are likely to exhibit the same defect. In automotive, successful traceability where the source of the issue is discovered can mean the difference between a significant public recall of thousands of cars versus a controlled scenario in which the service of a few hundred cars, the ones known to be affected, is offered.

The second requirement often placed on production is conformance to designated operational standards. This is an attempt at reducing defects in the operation that affect quality by making every operation follow a defined procedure, with built-in checks to ensure that everything is performed correctly, in the right sequence, and with the right setup.

Unfortunately, both of these requirements usually lead to an increase of cost where additional manual operations or recording of operations need to be made. They can also reduce productivity by introducing additional processes or by having to stop the processes for the recordings to be made. A lack of confidence in any manufacturing process can lead to the mandating of business crippling procedures.

How the Valor NPI solution can help
• The Valor solution continuously collects key information about materials and processes throughout the manufacturing operation, such as the collection of test results, tracking of production units from place to place, placement of materials etc
• Almost all of this information is collected automatically and associated directly with each specific production unit, which creates a complete traceability build record that includes all manufacturing, assembly and test processes
• The Valor software for production, planning, and materials establishes best practices and enforces and checks correct operation as part of the standard operation; for example, verification of materials at the time of machine setup where the machine cannot be started until all of the materials have been verified
• The traceability build record is created with minimal additional product cost or effort because it’s a built-in part of the operation and is comprehensive across the whole manufacturing operation, not just confined to SMT machines
• The Valor software can provide analysis and reporting of the full traceability build record on demand, so that any issue can be quantified and contained at a moment’s notice
• The benefits of conformance and traceability by the Valor solution include the reduction in the scope of needless product recalls, quality improvement and costs saved from the correct assignment of responsibility for any issue detected, for example, to the material supplier. The costs of ownership and operation of these additional requirements on manufacturing are minimal compared to manual data-gathering solutions
Step 8 – Seamless operational management

Because of the complexity of the SMT production operation, different teams have different roles across the shop-floor, each with different motivators and incentives. The performance of each team is measured in different ways. This can lead to “silos” of responsibility, where operators, engineers and management may not work together between silos in the best possible way to resolve issues, choosing instead to avoid responsibility.

Such silos commonly encountered are production operation, production engineering, planning, supply-chain, quality and industrial engineering. Where issues arise, each of the teams has a different perspective, often leading to a situation that conflicts with the other teams. As a result, some issues go unaddressed because the solution is perceived to be more of a cost than the issue itself. Improvement initiatives within one team may have detrimental effects on others, creating so-called “flavor of the month” improvements that disappear rapidly once attention becomes focused elsewhere. The ultimate common goal of the business is not helped by this situation because it limits real improvement and opportunity.

How the Valor NPI solution can help

• The Valor software on the shop-floor is built around a single common infrastructure so that everyone has a consistent view

• Diverse information coming from many different aspects of the manufacturing, assembly, and test operations is qualified, accurate and timely, so that everyone gets the same information, albeit from a different perspective, from the same source

• The different teams in production work more effectively together, avoiding differences of opinion, and everyone can work toward a successful conclusion

• Benefits include improved productivity and quality, as responsiveness to issues increases, fixes stay fixed, and a much more harmonious shop-floor working environment is created. In this situation, key roles are happy to address challenges. For example, as delivery demand changes, planning changes can be made and executed by each team whose actions are simply part of their normal operation
The age of automation within SMT manufacturing is now extending from the machine and mechanical level strongly into the software area. The complete manufacturing operation now needs to be considered whenever delivery changes are needed to follow market demands. The complexity of the SMT operation is too much to be managed without automated use of key data. The Valor software provides a unique combination of support for these key areas, providing automated control mechanisms as well as a higher order of information for management purposes.

Increased product complexity, larger numbers of product variations, shorter product cycles and a near non-existent distribution chain means that the volatile demand patterns from customers, driven by, for example, the latest fashionable technology and energy saving devices, puts factories into a position where a step change improvement in the flexibility of supply from the operation is required. The issues that manufacturing faces are not new in themselves, but, it is the scale at which these issues are today increasing that drives the compelling need for change. Valor software from Siemens Digital Industries Software provides real solutions to these problems.
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