How Do You Reduce Costs, Risks, and Improve Product Quality Lead-Time?

DFX

A Product Design Strategy Approach.

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In today's world, companies face product price pressures and long-lead times on electronic components. Product companies with electronic hardware have increasingly looked at ways to combat such challenges. You have probably heard of DFM (Design for Manufacture) and DFT (Design for Test), but with 60% to 80% of a product unit price being component cost and directly impacting Lead-Times, no product strategy is complete without DFC (Design for Component Cost). Additionally, many high-complexity and high reliability product designs cannot tolerate field failures or high manufacturing scrap rates so DFQ (Design-for-Quality) is also a critical aspect of a product strategy. The DFX (Design-for-Excellence) process then brings these four primary disciplines together into a complete product strategy, taking their synergies in consideration for maximum product design and life-cycle performance.

There are many compelling reasons for doing a DFX review as an integrated process with your design and NPI process. Then why don't more companies include a DFX in their new product designs? The DFX process appears to be expensive, lengthy and resource intensive to implement. However we have found that if properly integrated into the project timeline, the amount of time and resources is minimal compared to the normal product development cycle. In the rush to get a product fast to market, many product companies lack the necessary tools, methodology and collaboration expertise to bring all necessary functions (Supply Chain, Quality, Design, Engineering, Manufacturing, Test, After-Market Services, Logistics) to make the DFX a natural extension of the product development process.

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Benefits:
The DFX process has many benefits. Some of the obvious benefits include:

- Product Material Cost Reductions
- Lead Time Reductions
- Quality Improvements
- Product Risk Reductions

The benefits of DFX are realized over the product life-cycle and can greatly impact an organizational competitiveness and market growth. Other benefits such as increased customer satisfaction, cost avoidance on recalls, and overall value creation are staggering to an organization long-term. As more companies are reaping the huge benefits of DFX, these companies are using DFX, or a form of it to truly differentiate themselves in the market place and compete more effectively on a global scale.

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Is your product design team ready for DFX? If so, the following process outlines an approach that was developed and successfully deployed on several products at leading electronics contract manufacturer.

Developing Product Strategy

The DFX process starts with a detailed product strategy analysis. The product strategy analysis is often overlooked, but it is a critical enabler for many of the decisions that will need to be made in the individual reviews, and will help to resolve conflicts of sub-optimization.

Gathering Product Information: The product strategy analysis starts with the gathering of critical information in a form of a checklist of questions that the DFX team must ask prior to starting the DFX. The product design team will have some of the answers, however much of the information will need to be gathered from various departments. These departments include marketing, raw material suppliers, quality logistics, and management groups responsible for the product. The product strategy includes market, product specific information, import/export costs, supply-chain, fulfillment, test, manufacturing, quality systems, and product servicing. This information gathering and overall product strategy formation is a critical first step in setting up the supply chain, manufacturing, and global fulfillment strategies.

General Technical Product Strategy: Developing General Product Strategy is a key ingredient in the product strategy analysis. Questions regarding expected life of a product, upgrades, and variations supported, cost targets, and esthetic requirements for packaging, and more, will need to be answered.

Product specific information is just that, specific detail about the product. Is the product new or a subsequent revision of an existing product? Is it a component, subsystem or complex systems integration product? The answers to these and other product specific questions will lead you down the path of gathering critical pieces of information about the product being considered for DFX.

Product Fulfillment Strategy: The product fulfillment strategy includes questions about the end customer and the overall product market landscape. Where will target customers be located geographically? If customer demand is dispersed, what minimum volumes are requirements for shipments? What about tariffs, harmonized codes, intellectual property (IP), or trade agreements for each geographic region? What are the customers' delivery and availability expectation? Next day, one week? Does weight and size affect logistics costs? Are options available for different configurations ordered? Formalizing the supply chain with the lowest total cost will depend greatly on getting accurate answers for fulfillment and market requirements to address a competitive Global Product Fulfillment Strategy.

Raw Material Strategy: The raw materials strategy is roughly defined during the product strategy analysis and will be further refined during the Design for Costs/Components (DFC). Questions raised here include: Are there similar components on other products that can be combined to provide purchasing volume leverage? What about alternate components, Not-Recommended-For-New-Design components, RoHs compliant, obsolete components, Lead-Times, etcetera? Custom component lists are developed to identify local procurement opportunities and custom component DFC requirements. Many other aspects of the materials strategy are identified at this stage to help guide the component and supplier selection process.

Product Maintenance/Service Strategy: The Product Service Strategy also needs to be understood up front. Where are the products installed? Indoors, outdoors, at sea, underground? While performing service or upgrades, is the unit taken out of the service, or does it remain in operation? Who will perform field service? If required, where will the service center(s) be located geographically? Is the product going to be recycled or refurbished? Can the product be designed to be serviced more efficiently and effectively? Are upgrades needed in the field? These and other questions begin to clearly point out requirements for various elements of the overall product strategy.

Product Quality Strategy: The information collection and quality strategy is intended to develop not only the inspection criteria, processes validation, and test, but also the product manufacturing data collection and reporting strategy as well. IPC or other inspection standards need to be understood, especially if a higher standard is required, such as regulatory intensive industries like medical, aerospace, or even automotive. Compliance to ISO 9001, 13485, AS9100 TL9000, or TS16949 may also be a consideration. In some cases, certain end-customers require certain reports, tests or certifications to be provided online, automatically, or with each product shipment.

Setting the Tone: Product Strategy Analysis: The product strategy analysis portion of the DFX sets the tone for the remaining reviews and overall product development and design. Completing this section of the overall DFX process lays the groundwork for all of the subsequent DFX tasks. Therefore its omission or reduction of scope may

cause delays, sub-optimization, and non-resolvable conflicts in the DFX process. After the successful completion of the product strategy analysis, the company is ready to move on to the determination of the reviews required by the specific product.

Product Review Requirements

Some products lend themselves better to the DFX review process than others. High cost or high-volume products are the best candidates for DFX due to the potential effect on unit price. It is important to note that unit price is not the only benefit of DFX, therefore many additional products are candidates for the DFX process.

"High Cost, or High Volume Products are the best candidates for DFX"

There are certain matters to determine which design review techniques and strategy development methods are to be employed on each design. The review team or Project Manager must look at each element of the DFX and each discipline to establish project review scope.

The review is separated into 4 disciplines; DFM, DFT, DFC, and DFQ. The individual disciplines are then divided into several sections to encompass all activities.

DFC – Design for Component Cost

- Commodity Strategy
- Custom Component DFX Feedback
- Alternate Component Review
- Supply Chain Qualification and Monitoring Strategy

As mentioned before, 60% to 80% of a product unit price being component cost and directly impact Lead-Times. DFC is a must when completing a DFX. The DFC review includes a complete BOM review for sole source, End-of-Live (EOL), Not-Recommended-for-New-Design (NRFND), alternate selection, Lead-Times, and component qualification. In addition, a commodity strategy is formulated for each part and the risk or cost impacts of various optional strategies are analyzed. These tradeoffs are reviewed and a recommendation is made for the optimal strategy for each commodity. Alternate component qualification builds are scheduled for each part under investigation. Qualification build approvals and subsequent ECO's to add alternates to the AVL are tracked automatically.

Custom components offer great opportunities for supply chain cost reduction. Each custom component goes through a design review checklist specific for the commodity type. The goal is to optimize the quality, delivery, availability, and cost with the custom part supplier while the design is still not firm. Changes can be made to better fit the component supplier's process.

The supply chain engineering team is actively involved in component and supplier selection. Supplier selection, qualification, audits and ongoing supplier monitoring for quality, delivery, availability, and cost are all part of the supply chain engineering activities. Supply chain cost and inventory management can be optimized utilizing local suppliers and JIT (Just-In-Time)

and VMI (Vendor-Managed-Inventory) delivery of components.

DFQ – Design-for-Quality

- Projected Product PPM
- Product Reliability Plan
- Process Control Plan
- Process Automation and Monitoring

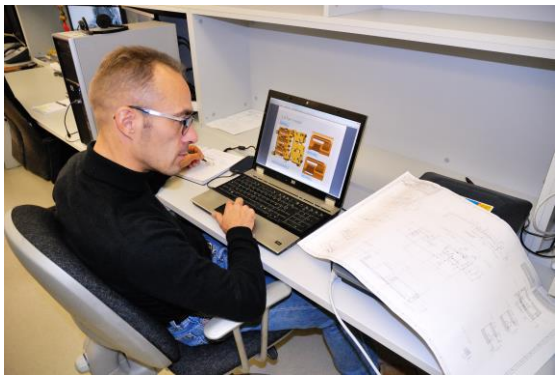
The manufacturing and test processes are divided into individual operations and analyzed for exposure to inherently high PPM processes. These processes are then reduced, eliminated, or automatic monitoring in the product design to reduce PPM levels significantly. Critical processes are identified and special control techniques are defined and developed. These control techniques include tooling and process improvements, where possible, rather than inspection or testing. The philosophy is prevention rather than detection.

Process control plans and product reliability calculations are done based on component and process level reviews of the design. Alternate components and processes are recommended, and automated monitoring techniques are provided as required. Process control plans also determine the capability of the systems used in the production process and define the control limits to be used in the automated process control and data collection system.

The DFQ process is integrated into the quality system of manufacturing facility and will take on additional attributes based on the level of certification. For example the telecommunication specification, TL 9000, requires metrics to be recorded, tracked, and sent to third party storage. The automotive specification, QS 9000, TS 16949, or equivalent requires, APQP, FMEA tools and other controls. These tools and techniques must be made available as part of the DFQ to be able to handle all product requirements.

During the qualification build phase of the project, all processes are verified for reliability and repeatability using Cpk analysis techniques. All suspect component issues are worked immediately and a component failure analysis lab is used to isolate the defect. A quick component FA is critical during this stage, as it may result in alternate component selection or design change.

The DFQ process can also establish requirements for agency approvals, UL, FDA, and more. These approvals require design and process level support and must be considered in the early stages of the product design.



DFM – Design for Manufacture

- Manufacturing Strategy Development
- Detailed Requirements Checklist
- Automated Design Rule Check Tool
- Manufacturing Summary
- Product DFM Utilization Report

The manufacturing review is partially automated using standard guidelines input to a design rule checking software package. CAE tool outputs are used as inputs to the DRC, with the results being fed back into the design team. In addition, there are design guidelines that cannot be verified using a DRC type verification tool. These guidelines are in a checklist format, then a manual review of the design results in verification to the established standards. Several iterations of the review and re-design may be required. After the design is frozen, there may be some design rule violations remaining. These violations may require special processes or tooling to be developed.

A strategy for manufacturing the product is developed and all critical processes and design rule violations are identified. Tooling is designed to control or monitor many aspects of critical processes. Process development activities may be required for any new technologies and processes. The product DFM Utilization Report can be used to track the design rule violations and the design recommendations that were not utilized in the design.

DFT – Design for Test

- Test & Inspection Strategy
- Detailed Requirements Checklist
- Automated Platform Testability Report
- Test and Inspection Summary
- Product DFT Utilization Report

The product test review process utilizes automatic software driven product review tools. The output from these tools may result in design changes during the component selection, parts placement, and routing phases. Several iterations of review and product re-design may be required. The manufacturing, component, and quality reviews may result in conflicts with the test review process. It is critical to communicate these changes as they occur and get approval from all groups prior to finalizing the design.

During the review process, an accessibility worksheet is filled out to establish how accessible the product is to various types of test and inspection tools. From this worksheet, electrical, optical, and x-ray accessibility can be determined, which will drive the final decision as to what the best fit test strategy is for the product. At this point a decision needs to be made to add additional accessibility to enable reduction in complementary strategies, or to make a conscious decision on cost versus test coverage.

Combination test strategies are being offered by some of the test platform vendor. These complementary testing strategies can provide better test coverage with lower redundancy than single technique strategies. They are often employed in high reliability applications and high-speed designs when electrical test coverage is limited.

Test and inspection points in the process should employ some type of automated data collection as a process control and data collection tool. The more automation in this area, the better. Automation will result in higher integrity data and will help in the shutdown process for out of control events. Data collection can also be used to track time to failure and other data.

This can be used to reduce, remove, or otherwise target specific areas for test coverage. It typically results in cycle time improvement and cost reduction.

Many times an optimization in one of the four review areas above (DFM, DFT, DFQ, & DFC) can adversely affect the cost, quality, or delivery of a product with respect to the other three disciplines. For this reason, the overall DFX review is used to make decisions that avoid sub-optimization of the whole and provide the best overall product strategy at the lowest total cost, best delivery and quality.

DFX – Design for Excellence

- Product Strategy Analysis
- Deployment Benefits
- Implementation Plan and Schedule

The DFX process encompasses the DFM, DFT, DFQ, and DFC disciplines and attempts to gather all recommendations from each of the areas. Then after considering the risks tradeoffs between the different disciplines, a final recommendation will be made. The DFX output is really an executive summary of the combined activities in the four review areas. The overall DFX does take more time and adds more time to the product develop and design schedule, but the benefits can prove to be enormous in overall better costs, quality and lead times of the product.

Many product design groups only utilize DFM and DFT reviews because they have short cycle times and do not cause large delays in the project life cycle. By omitting the DFC and DFQ, the product design suffers from potential quality and reliability issues, and almost certainly will have a sub-optimized supply chain strategy. To fully realize the benefits of DFX without affecting the project timeline, careful consideration must be taken to properly integrate DFX into the product design and NPI process.

Integrating the DFX into your Design and NPI process

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The implementation details of the DFX will need to be defined to be integrated into the product design and NPI process. If any part of the DFX becomes a task on the critical path, it will draw scrutiny by the Project Manager. To prevent DFX tasks from being on the critical path, you must integrate the standard design and NPI Gantt chart with the DFX process steps. It may help for you to create a data flow diagram that shows the inputs and outputs from each step in the DFX in order to understand better its relationship with the product design and NPI process.

After the data flow is understood, identify when those documents are currently created with the correct level of accuracy for the DFX activity to use the data. Adding the DFX activities then becomes very easy during a first pass Gantt chart review. You may find that some of the preliminary data generation steps need to be moved up in order to accommodate DFX activity completion before those results are then used in critical design reviews and phase exit reviews.

Executive Sponsorship:

Most companies that are successful in DFX implementation have an executive sponsor at a very high level in the organization to support the strategy. Executive sponsorship is critical, for the success of the DFX relies on many cross-functional teams working in concert with one another. Teams such as R&D must work together with Marketing, Quality, NPI, Materials, Legal, Test, Engineering, Manufacturing, After-market Service and Logistics. A truly effective DFX involves all necessary parties to capture maximum value of the product DFX methodology.

Conclusion

Implementing DFX on new and existing products can certainly have a positive impact in an organizational competitiveness. Typically department evaluating of DFX only looks at cost impact to the unit product costs, but as the product is developed and the DFX process is implemented, wide positive impact addresses major issues across the organization. Cost Reduction is the obvious benefit. Much like an Iceberg, DFX addresses less obvious cost, quality and risk impact of product that are not obvious before the DFX implementation. As mentioned during the Product Strategy Analysis, questions such as serviceability, IP Protection, and logistics can add tremendous risks and costs if not addressed initially. In addition, other product support costs that normally occur in the sustaining engineering area can be reduced or eliminated. The reduction in design re-spins for obsolete components will reduce costs and improve new product development team effectiveness on new products. Improvements in quality will translate into lower TDR (Test Debug and Repair) costs and a reduction in scrap. These cost saving opportunities are critical to the long-term success of a product development team. They will manifest themselves in shorter time-to-market, less sustaining support requirements, and lower total cost. Designing a product maximum effectiveness when product is been serviced, can substantially add value and reduce risks to the product value chain.

"…DFX total benefits are not always visible immediately, but make a huge impact in an organizational portfolio of products and overall organizational value creation."

So like the Iceberg, DFX total benefits are not always visible immediately but make a huge impact in an organizational portfolio of products and overall organizational value creation.

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