Guidelines for Ensuring PCB Manufacturability

Author: Nolan Johnson

Overview

The rules of PCB design have changed little over the years, but the demands on the boards themselves keep increasing. The need for smaller, more complex boards used in smartphones, tablets, and other handheld devices translates into less real estate for greater functionality.

Design for Manufacturability (DFM) now plays a more important role in the production process. The continued miniaturization of products means that many designs push the physical limits of PCB manufacturability. This makes poor performance or even failure more likely.

Good DFM techniques are more important than ever. This paper explores a number of straightforward ways you can increase the manufacturability of your boards.

Addressing the Issue of Design Tools

When working to prevent manufacturability problems, address the issue of design tools early on. DFM plans ahead for the manufacturing process and considers yield and other manufacturing issues that affect cost and quality. With numerous free or low cost resources available to designers and engineers, it is possible to more easily integrate the design and manufacturing processes. Manufacturing requirements and capabilities can be accurately reflected in the design work.

Designers can use multiple design tool types to create DFM-optimized designs. Each tool type is best suited to a particular usage:

Usage Requirements	Tool Notes
Best Performance Most Thorough Rule Checking	Standalone and web-based DFM clients can be generally referred to as back-end DFM tools. While these tools often have the best performance and most extensive ability to find DFM rule-set violations, they can also be a bottleneck. The cost of fixing design flaws tends to increase in geometric proportion to how late in the design cycle flaws are identified.
Most Efficient Design Process	Interactive DFM tools can increase efficiency. Because back-end DFM tools require a round-trip of some sort between the design tool and the DFM tool, their usage inevitably interrupts the design process. On the other hand, interactive DFM tools give insight into how design choices will impact the yield or manufacturability of their design while they are working in the design tool. This helps designers make more robust design decisions. When a designer can get as-you-go reporting of a process violation, they can fix that violation immediately and inexpensively.

How you approach designing PCBs is an often-overlooked contributor to the ultimate quality and manufacturability of the boards.

Start Your Process By Planning Ahead

Good design process trumps heroics every time. Fortunately, there are simple ways to optimize the board design process.

Overall Process Considerations for Back-end DFM Tools

If you are not using a real-time DFM tool, you will want to consider how to integrate your back-end DFM tool into your design workflow. A back-end tool will identify what's expected to be a large number of design violations, warnings, and suggestions. To manage the information that is returned, you have three common processes from which to choose:

Option	Description	Notes
Option 1	Fewer full-functionality full-design checking runs; longer results-review phases	• Most thorough rules checking • Identifies the most errors overall • Increases the chance of missing a critical error • Can cause a rip-up and re-route, costing time and causing errors
Option 2	Run full-functionality checks on portions of the design; use one full-design run at the end for a final check	• Commonly used for checking modular designs • Can miss violations between subcircuits • Not as comprehensive as a full-functionality run
Option 3	More iterations using focused-functionality runs; more short design reviews	• Delivers some of the just-in-time rule-checking benefits of a real-time tool • Minimizes the potential for expensive routing rework • If a fully interactive verification toolset is available, use that instead

Manufacturer-specific Process Considerations

Even after *your* design process has a completely dialed-in DFM element, there are common pitfalls to keep in mind. By understanding these common process-related problems, you can work around them and save time:

Common Process Problem	Solution Discussion
Poor communication with manufacturer	Even when outsourcing PCB manufacturing, close communication between you and the manufacturer is extremely helpful. In fact, communicating with your manufacturing partner at the beginning of and regularly throughout the design process is ideal. Your manufacturing partner has valuable insight into how design decisions can impact cost, manufacturability, yield, and quality of the boards you are designing. Don't wait until the design hand-off time to communicate with them. If your manufacturer has response telephone or e-mail support, you can use their expertise to fill gaps in your own.
DFM ruleset mismatch	One of the first orders of business when starting a new project is verifying that you and your manufacturer are using consistent DFM rule sets and component footprint files. The other communication link you should be careful to cultivate is with your supplier(s). The typical designer may have to manage a library of about 10,000 parts. Just as your board manufacturer's capabilities and process requirements have a large impact on the manufacturability of your design, the accuracy of the footprint files you use on your board also affect the design's success. Don't be shy; like with your manufacturer, keep an open line of communication with your supplier(s) to help guarantee that you are using up-to-date footprint files throughout the design process.
Electrical performance problems in completed boards	PCB design is the interface between the perfect world of the schematic and the real world of the manufacturing facility. Particularly with high-speed board designs, you cannot optimize only for yield or other physical characteristics. This is because the electrical characteristics of the board can interfere with correct signal transmission. To avoid costly re-designs, use a simulation tool to balance the electrical performance of your design against other desirable physical characteristics like size and yield.
A design that builds fine with one manufacturer yet fails with another	If you are using a rapid prototyping service for your PCB manufacturing, be aware of any process requirements that may be specific to your manufacturer. For example, your board parameters may need to fit within specifications that are unique to that manufacturer's rapid prototyping service. As PCB manufacturers know well, highly manufacturable designs exist within a range of specifications. Good manufacturers can help you tweak your designs so they make the best use of range or wiggle room. If your DFM rule sets seem to be constraining a goal for your design, reach out to your manufacturer to see if there is some wiggle room in their DFM requirements. This kind of designer-manufacturer communication about DFM can help improve your design.
Tolerances violations	Remember to check tolerances at every level, both with parts and with manufacturing processes.

Design to Manufacturer Capabilities

Working with a PCB manufacturer makes life easier in many ways, but not all manufacturers have the same capabilities. A conservative design will likely provide you with more manufacturing options, but that does not eliminate the need to learn about potential manufacturers' capabilities before creating your design. Take the time to know what a manufacturer can do, so you avoid expensive rework.

When evaluating manufacturers, pay special attention to the following:

Evaluation Point	Recommendations
DFM ruleset offerings	Design for manufacturing may as well be called design for the manufacturer, meaning the specific manufacturer you will be working with. Contact your manufacturer early in the process to make sure you are using DFM rules that match the manufacturer's specifications, or that they can provide a DFM rule set that reflects their specific capabilities. If you are unsure what manufacturer you will use, design conservatively, so that your board can be manufactured in more than one place.
Front-end expertise	When shopping for a PCB manufacturer, be very curious about their internal process they used to move a design from a CAD file to completion. In particular: • What kind of DFM checks happen after they receive a file? • How robust is their DFM and quality assurance (QA) process? • If they receive a design that has manufacturability problems, how will they work with you to resolve the problem? • What is their scrap rate? A manufacturer's scrap rate is a single metric that serves as a good proxy for other important efficiency and quality-related metrics. A low scrap rate tends to indicate that a manufacturer has good internal DFM and QA processes. Questions like these will help you identify manufacturers with a robust DFM process that can help compensate for any gaps in your DFM expertise.
Support capabilities	In the same way that interactive DFM tools help you learn about manufacturability problems before you complete a design, choosing a manufacturing partner with readily available support staff can help you solve manufacturability puzzles during the design process rather than after submission. As you are evaluating PCB manufacturers, pay close attention to their support capabilities. Do they make it easy to get competent technical support? How quickly will they respond to your needs? How can you get support for time-sensitive issues other than by e-mail? Are they available 24/7/365? What is their escalation policy for difficult support requests? Is support free or is it pay-per-incident? Probing questions like these are important, and best asked before you settle on a manufacturing partner for your projects.

Conclusions

The most fundamental guideline you can use is to consider DFM earlier in the process rather than later.

The key to optimizing the manufacturability of your PCB designs is to choose tools, processes, and a manufacturing partner with capabilities that meet your needs. The most fundamental guideline you can use is to consider DFM earlier in the process rather than later. The best PCB design in the world will fail if parts don't fit or are not pinned out correctly.

Where possible, use a PCB design tool with interactive DFM rule-checking capability. If that is not an option, tweak your design process to use multiple partial-functionality checks rather than a single full-functionality check at the end of the design cycle. Treat your parts supplier and PCB manufacturer as members of your design team, and make communication with these vendors throughout the design cycle a pillar of your process. Use simulations where necessary to avoid expensive product performance surprises.

The right manufacturing partner can make it easier and cheaper to get to a working prototype. Look for a manufacturer that provides free, up-to-date DFM rule sets and product support that meets your needs for accessibility and expertise. And be sure to find out what their DFM and QA processes are like, because that will also have a significant effect on your product's cost and quality.

Author:	Nolan Johnson
Author's title:	CAD/EDA Manager
Author's e-mail address:	njohnson@sunstone.com
Author's contact info:	Sunstone Circuits 13626 S. Freeman Road, Mulino, OR 97042 (503) 829-9108