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Siemens Digital Industries Software

Online DFM analysis for better products, faster

Cloud-based tool for collaboration between PCB designers and manufacturers

Executive summary

Design for manufacturing (DFM) analysis ensures that a printed circuit board (PCB) layout passes manufacturing requirements before production begins. This process often takes days of going back and forth to adjust the design. As part of the Xcelerator initiative, Siemens Software has created a cloud-based solution that reduces validation to minutes. Designers can log in to the secure online service and run DFM analysis against data from a selection of PCB manufacturers to select the one that most closely matches their needs for production.

The combination of DFM and easily working with a capable manufacturer early allows designers to maximize the quality of their products. The result of design-executed DFM based on specific manufacturing requirements also means fewer callbacks and higher yield for the manufacturer. This paper describes the new tool and provides some use-case examples, as well as testimonial from an early adopter.

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Barriers to shifting DFM to design

Simulation and digital twins have enabled designers to do more up front, analyzing and testing their designs, conducting virtual prototyping with many iterations, for many aspects of the design before it goes to manufacturing. The number of NPIs is growing exponentially as the demand for electronics is increasing across all industries. Simple, accessible and intuitive tools are needed to help manufacturers deliver products to the market on time. They are looking to increase early stage involvement at the design phase to be able to meet the demand for speed.

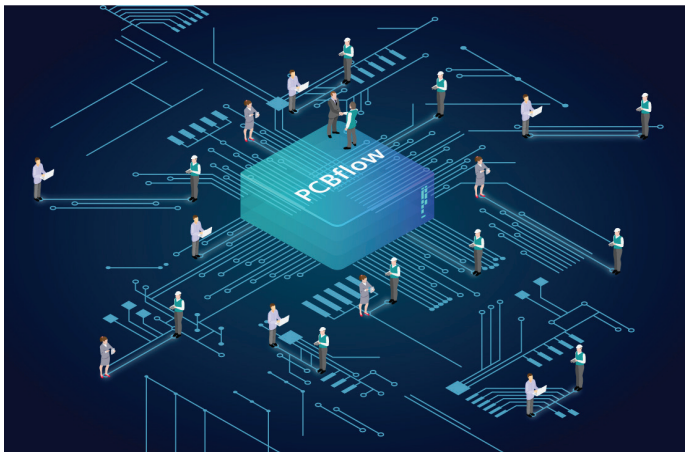
But there has been a gap — PCB designers have not had quick and easy solutions for DFM to ensure that their build matches the specific manufacturer's requirements, before it is shipped to the factory. The electronics industry has been trying to shift design for manufacturing (DFM) further upstream in the product production process with variations in success, but for this practice to be successful, design engineers and manufacturers have to be willing and able to share information.

Even when designers are provided with the best-in-class DFM applications, a primary obstacle to shifting DFM checking to the left is often the reluctance for manufacturers to be as transparent as needed. Suppliers also are often not readily willing to cooperate despite all the benefits, because of IP ownership and security issues. Even when done entirely in-house, product design in traditionally is separate and isolated from the manufacturing process. This siloing often results in one-to-several redesigns to make the product manufacturable, adding time and cost to the project. This results in only partial manufacturing needs taken into consideration early in the design process. The fallout means many technical queries, inefficient data exchange, and avoidable revision spins.

One of the biggest challenges in the process of a design to manufacturing handoff is the lack of manufacturing knowledge and data while still in the design phase. Often, there is no communication between designers and manufacturers. Handoff to manufacturing typically is managed by the procurement department.

Procurement for PCB fabrication is important, but it also crucial that the PCB design can be done by the fabricator. Without direct communication between the designer and fabricator during the design stage, the designer finds out that the product does not comply with the manufacturer's constraints, or a fabricator discovers that they are unable to fabricate it, late in the process. Both designers and manufacturers say this is the main source for project delays, business loss, as well as low closing rate and manufacturing capacity.

Supplier business-to-business (B2B) networks use various communication methods to exchange data between buyers and suppliers: emails, communication over phone, negotiations, business deals, contracts, quotes, invoices etc. The data exchanged from design to manufacturing needs to be secure.



Siemens engineers have created a solution to solve this problem to enable online DFM. They realized that for such a solution to be a reality, communication between designers and manufacturers has to be direct, timely, easy and secure. They built a networking platform, called PCBflow, that designers and manufacturers can use to connect and securely share data while still at the design stage. It is a cloud-based solution, with Valor NPI under the hood.

Online DFM

Software as a service (SaaS) is becoming more common. It eliminates the need for local client software installation and configurations. These cloud solutions should incorporate strict security standards, reducing risk and protecting intellectual property (IP) for companies and individuals to use them with confidence and assurance in their data protection. PCBflow incorporates the strict security standards of Siemens software so that manufacturers can feel safe sharing their manufacturing constraints, and designers feel safe running DFM analysis for their products. With PCBflow, both parties can be confident working together in a secure cloud environment.

PCBflow enables quick and secure connections between an OEM and EMS company or designers and their manufacturing partners. OEMs and designers can share their PCB designs, while manufacturers and EMS companies can share their manufacturing constraints.

Security is assured because the connection requires approval of both sides. Once a connection is established by the request's recipient, PCBflow collaboration is enabled between the two parties. Manufacturers can upload and privately share their advanced manufacturing rules with their approved designer network.

Through PCBflow, designers and manufacturers can communicate directly and exactly how they need to for exchanging information. By sharing data at an early stage, the design can be validated against the manufacturer's specific constraints, accelerating the handoff process to manufacturing.

For the manufacturer, when a board is released, it often has issues with the design that can negatively affect yield. Asking the designers to correct the issues usually involves lengthy phone calls or emails, which costs time. With PCBflow, fabrication capabilities are communicated electronically, allowing the design team to design directly to your requirements. Customer access to the manufacturing process capabilities is controlled and secure. The result of design-executed DFM based on fabrication capabilities means fewer callbacks and higher yield.

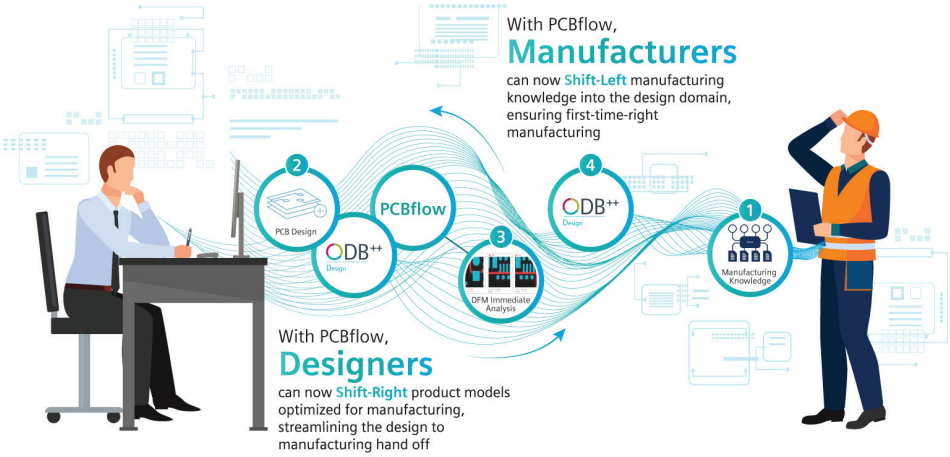


Figure 1. An instant DFM analysis, based on valid manufacturing set of constraints.

Manufacturing capabilities can be communicated electronically. With manufacturing-specific capabilities built into PCBflow, designers can ensure manufacturability, saving time. Providing manufacturing knowledge to designers builds teamwork and collaboration, which results in fewer callbacks. Customer access to process capabilities is controlled and secure. With PCBflow, manufacturing capabilities can be provided to an expanded audience, increasing the conversion rate of new customers.

Ensuring manufacturability for designers

For small-to-medium–size design houses, the further along the project goes, the more it costs to fix an issue. Small- and medium-sized businesses are looking for agility and are willing to pay for fast and reliable services. They are producing smaller batches, which means greater overhead for the manufacturer. PCB DFM analysis is the way to address this issue, however, up until recently it was performed mostly by top global OEMs, making complex and highly regulated products (e.g. defense electronics, communications, and medical).

With PCBflow, the designer can explore the capabilities of many manufacturers and select the one that most closely matches the requirements. PCBflow incorporates specific manufacturing knowledge for the selected partners, allowing process-driven DFM. DFM analysis can be done at any point in the design process, without having to be an expert. The combination of DFM and working with a capable manufacturer ensures maximum PCB quality.

Having the capability to run DFM at any time from schematic up to release allows any manufacturing issues to be discovered and fixed early in the design process, eliminating respins and saving both time and money. The product is released to market faster, with higher quality and at a lower cost.

PCBflow connects designers and manufacturer so that complete collaboration can happen throughout the process. This solution enables a closed-loop feedback mechanism that drives continuous improvement for both designers and manufacturers. With PCBflow, DFM analysis can be run at any time, in any location, even with mobile phone and tablets.

A uniquely flexible solution that incorporates on-premises tools to public and private cloud deployments, PCBflow helps to streamline the product development process by minimizing redesigns.

Figure 2. With PCBflow, DFM analysis can be done at any point in the design process, without having to be an expert.

How PCBflow works

PCBflow uses the Valor NPI DFM engine. Currently, PCBflow seamlessly supports the ODB++Design file format and IPC-2581. Additional formats are expected to be supported in the future.

Manufacturers can publish their DFM profile on PCBflow in a secured account and in a controlled way specifying who can access and use their DFM profile. This allows designers to run a DFM analysis against a real manufacturer profile that fits their preferences. The manufacturer's constraint set is stored in their secured account. OEM layout designers upload their design to their secured account to run DFM analysis on a selected manufacturer's profile. Manufacturability violations are sorted and prioritized according to the level of severity to guide the designer through images and locations on the product for easy discover and immediate correction. The result is fewer if any redesigns and the final design is much higher quality, maximizing yield.

PCBflow quickly qualifies potential manufacturers based on their competencies as matched to designers' requirements, so there is no need for lengthy research or email exchanges. This way, designers can know they are teaming up with a capable manufacturer and streamline their DFM flow. PCBflow is designed to guide layout designers easily to the manufacturability violation location in the design. PCBflow provides images, tooltips, measurements and location of the violation on the PCB design.

When logging into PCBflow.com, each registered organization is assigned a unique ID, and all of their data in the system is tagged with the organization's ID. PCBflow is a multi-tenant system that isolates resources from access by other tenants. Each request made to PCBflow is signed with an access token, which contains information on the tenant's identity, association and authorized actions. Requests are forwarded to the PCBflow services.

Here is what happens when a design or capabilities file is uploaded to the PCBflow service (Figure 3).

When a file is uploaded via a web browser, an HTTPS connection is established, which secures the connection to the services for any type of communication, including uploaded data. This means that files remain encrypted until they reached the service. Upon arrival to the cloud service, the data is decoded and forwarded to secured storage.

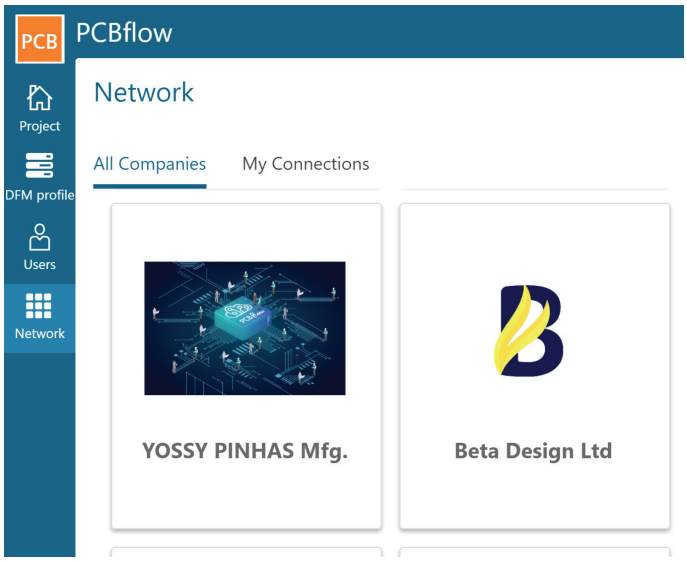


Figure 3. Example of online profiles.

When it reaches secured storage, the file is again encrypted, using an encryption key that is generated specifically for the tenant ID. The key is managed by a separate service and can only be accessed by an authorized tenant. The file is then stored in a separate, dedicated folder that is associated with the key ID.

When you make an access request – for example, to download the file again – the system checks the request against the defined privileges, and if the action is permitted, a relevant request for the tenant key is created.

Customer testimonial: Nistec

Nistec is a leading provider of electronic manufacturing services. It is comprised of four companies that together provide full service from design to the final product including layout, manufacture and assembly services for various industries, including communication, medical, military, security, industrial and vehicles. Nistec Design Bureau is located in the center of Israel and has 22 designers.

Designing a PCB is a highly complex process that includes thousands of decisions, each of which can be critical and lead to an error. Losses can add up significantly if a mistake is revealed after the manufacturer already purchased the components, if engineering hours were invested for vein, or if manufacturing is completed and the product is not working. To prevent that, Nistec designers run a manual internal check on the PCB design before sharing it with their manufacturing division. Checking all aspects of the design's manufacturability by hand is extremely challenging and time-consuming.

With dozens of new product introductions (NPIs) per month, time and efficiency are critical to getting their customers' products out the door. The design/editor has to define the manufacturability constrains per each job, which may differ from job to job. These preliminary definitions are crucial for the success of the production. Nistec wanted to improve their response time while maintaining their high-quality work.

They chose the new PCBflow (while it was still in its beta development stage) to help them in the process of evaluating their design and improving on it. Nistec CTO, Evgeny Makhline, worked closely with PCBflow Product Manager, Yossy Pinhas. Makhline ran tens of checks with PCBflow, and then shared his feedback with Pinhas, especially pointing out the most important parameters that PCBflow should cover.

For DFM tool they depended on an external partner who owns a solution, so it is not available constantly for Nistec. With this situation, Nistec designers have been using the DFM flow mainly for their most complex designs. Thanks to PCBflow ability to incorporate specific manufacturing knowledge for a selected manufacturer, shifting checks left into the design process becomes an automated comprehensive process. This reduces the potential for mistakes and increases PCB design quality significantly.

"PCBflow is a great solution, a win-win for board designers and for fabricators. On one hand, board designers get easy access to a cost-effective, easy-to-use platform that quickly identifies design issues and constraint violations that could affect manufacturability, and then connects them with a wide variety of fabricators. The fabs, on the other hand, receive a 'mature' design that requires little or no review or troubleshooting – a big saving in time and improvement of quality," says Makhline.

Usually, with an on premise DFM tool, the actual analysis would take three hours. Then, the iterations when communicating manufacturing requirements to the designer could take between one to three days. With PCBflow used on their simple designs in house, it takes one minute to generate the analysis report. For a complicated design, the DFM analysis takes up to five minutes. An overall PCB design check, conducted by the designer in charge based on PCBflow analysis report now takes only 30 minutes.

"PCBflow is a great solution, a win-win for board designers and for fabricators."

Evgeny Makhline, Nistec CTO

Case study: analyzing a complex high-density PCB with PCBflow

At the Siemens R&D facility in Munich, we ran different PCB designs through the PCBflow tool. We found that DFM testing time was very short even with highly complex HDI designs. Based upon the results, we were able to enhance the quality of the designs substantially with regard to manufacturing at improved yield.

The following is an illustrative description of our first use of PCBflow for a control PCB, which is the central controlling unit in a system with many sensors and mechanical components. Because of space limitations within the system, the circuit board contour is round with a 70.5-mm diameter. On this small disk, 550 components with 2,838 pins must be placed on both sides. To route this many components, which consists of a mixture of fine pitch active devices (ball grid array down to 0.5-mm pitch) and small passives (down to 0201 package size), a high density board (HDI) construction was mandatory. The board design was made with the Siemens EDA Xpedition layout system.

Figure 4 shows the placement of the components and the board construction. The board consists of an eight-layer core with one sequential buildup layer on each side. The connection between top and bottom layer to the core is with blind vias. Buried vias connect the different inner layers within the core.

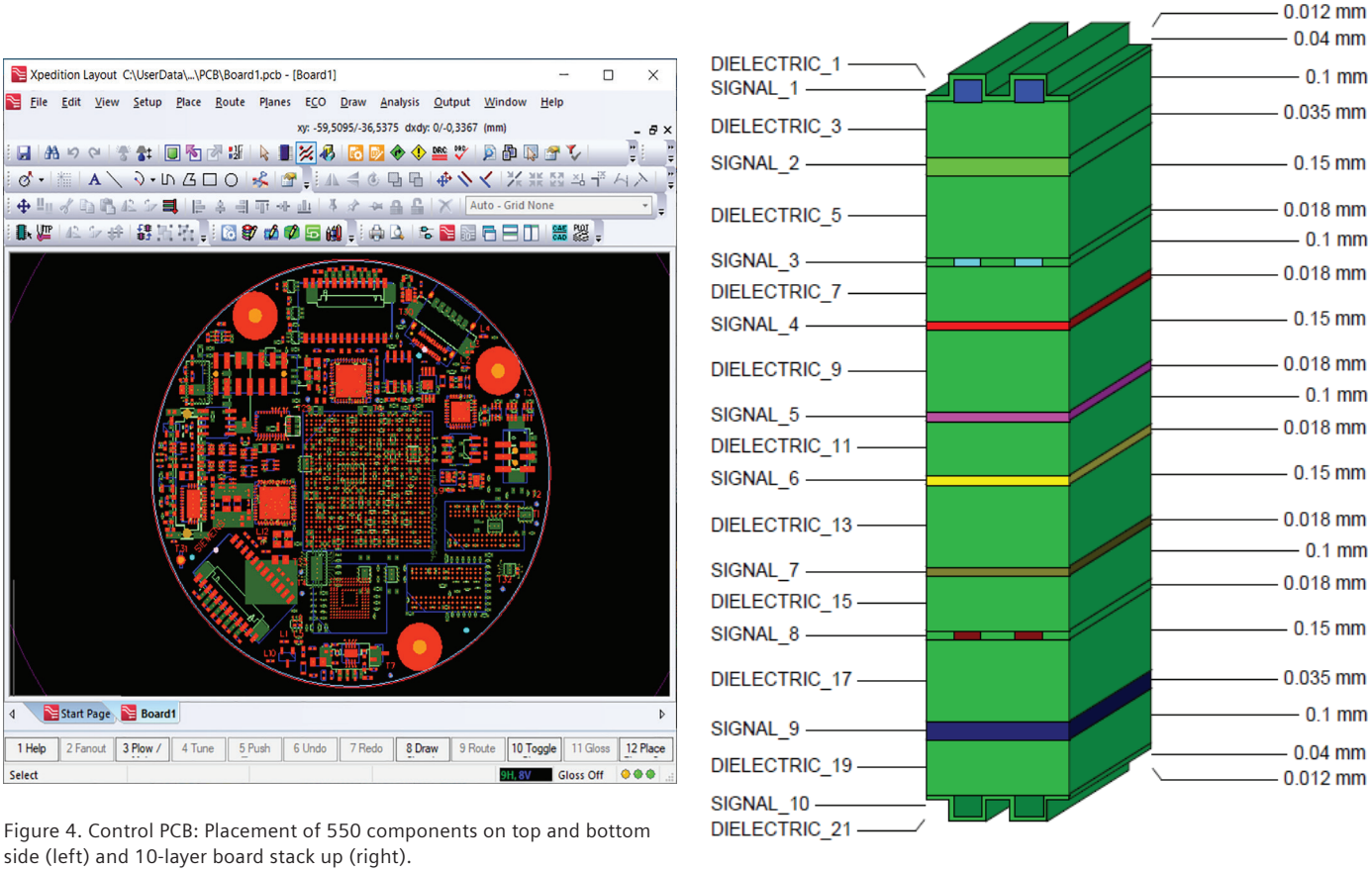


Figure 4. Control PCB: Placement of 550 components on top and bottom side (left) and 10-layer board stack up (right).

We then validated the PCB design against a DFM profile before sending the data out to a PCB supplier. We uploaded the design, which was saved as an ODB++ compressed file, to the PCBflow service and selected a DFM profile of a preferred PCB manufacturer (Figure 5). The manufacturer dashboard displays the company and location as well as the name and status of the DFM profile. Profiles with the status "public" are available to all users. Profiles with the status "limited" belong to companies that we are connected to within the PCBflow network.

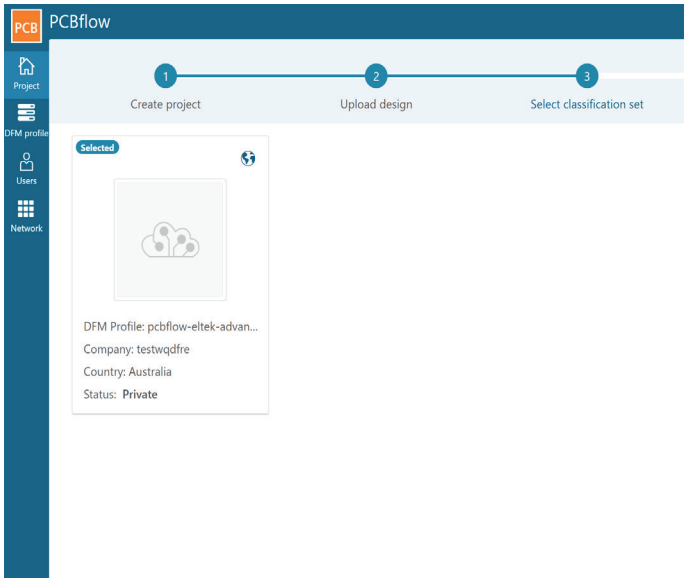


Figure 5. Design upload and selection of PCB manufacturer.

Figure 6. DFM report with information pane (left) and analysis results per layer (right)

The next step was to click the RUN DFM button to start the analysis process. Once the DFM analysis progress bar reached 100%, the DFM report was presented automatically. The complete analysis for this complex HDI board took only 90 seconds. The DFM report shown in Figure 6 is interactive and allows filtering as well as scrolling options. The DFM report consists of two panes. The information pane contains general information about the board as well as error statistics derived from the ODB++design data. The results pane displays the analysis results as a tree and provides controls for viewing and exporting the results.

Our DFM check of the control PCB identified a set of issues that could create problems during the production or assembly of the boards. Let us look at the selection of warnings and violations in more detail.

First, we can see a reduced copper spacing over a long distance between two tracks was reported on signal layer 3. Detailed information such as actual value (3.416 x 61.245 mil) and the *x,y* location of the error is provided (Figure 7). A feature that we appreciated is that you can see a description of the constraint when pushing the information button. According to the constraint tolerance range, the severity is assessed "yellow = warning." This tells us that the PCB manufacturer could have severe yield issues caused by electrical short circuits unless the distance between the tracks is enhanced.

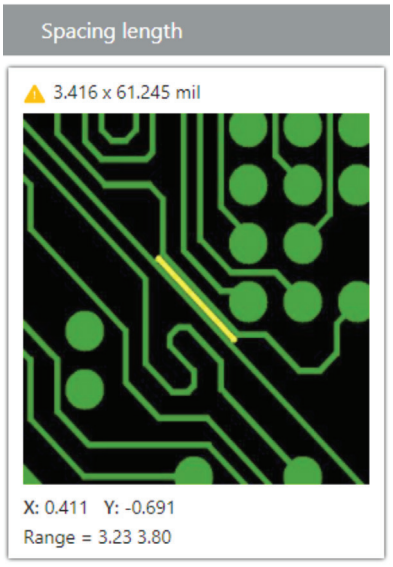


Figure 7. Spacing length issue as reported in the DFM report.

The DFM analysis detected several unwanted stubs on the outer layers (Figure 8). Because the distance between the adjacent copper structures is larger than the value set in the design rule check (DRC), those routing artifacts were not recognized during the layout of the board.

Figure 8. Copper stubs on outer layers.

And, because the pitch of the SMD pads is only 0.5 mm, those copper "noses" can result in solder bridges during assembly of the components. As a result, we removed all reported copper stubs.

Several warnings for stubbed vias were also reported. Buried vias between layer 2 and 9 of the core were only connected on one side. Those vias are useless, can cause a significant signal degradation and lead to higher drilling cost. We could improve the quality of our design by removing those buried vias.

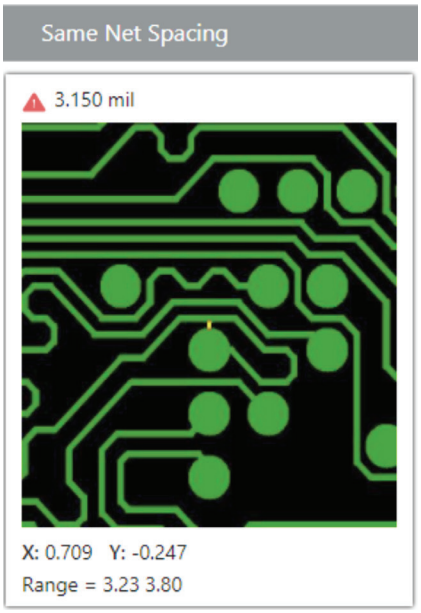


Figure 9. Constraint "same net spacing.".

A violation against the constraint "same net spacing" was reported on layer 3 (Figure 9). The small space between copper structures of the same net creates an acid trap. An acid-trap has the potential to trap chemical etchants used to strip excess copper from a board during the manufacturing process. When the etching solution pools in a certain area, there is a risk for corrosion of traces and creation of faulty connections or open circuits. So we changed the routing, keeping in mind the length matching requirement.

Our experience with running DFM analysis on this board, and many other experiments, in PCBflow, illustrated that we could improve the design in a very short time without any interaction with the PCB manufacturer during the layout phase. The finished product is shown in Figure 10.

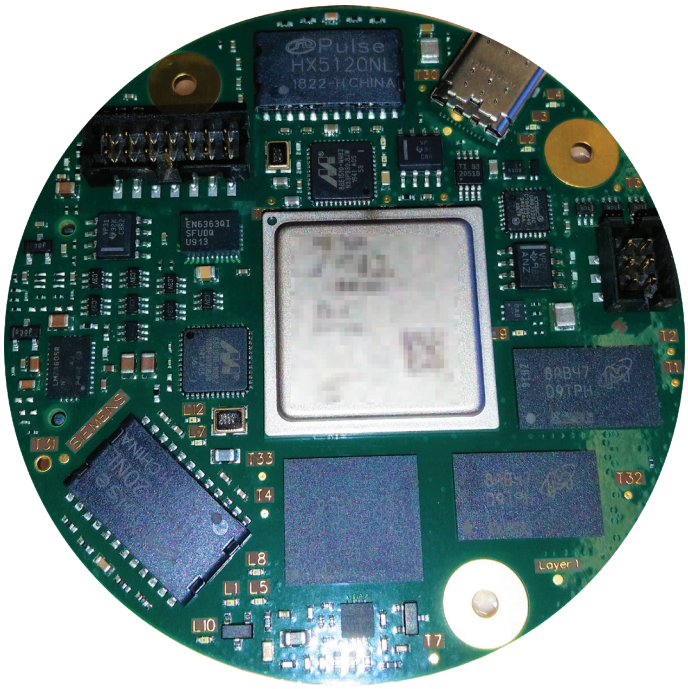


Figure 10. Assembled control PCB – view on top side (Design: T Lab Munich).

Conclusion

The PCBflow tool reduces the number of iterations between the designer and the PCB fabricator, supporting the delivery of first-time-right designs. As a cloud-based tool, PCBflow requires no installation and hardware. Designers can simply upload ODB++Design files into the secure cloud environment and select one or more manufacturers to apply process capabilities to the DFM analysis. PCBflow then guides through design violations, providing an interactive, web-based analysis and a downloadable PDF report for sharing.

PCBflow provides benefits to both designers and manufacturers. Because specific knowledge about the manufacturers' processes is integrated into the software, designers can run DFM analysis on specific manufacturing constraints at any point during product development. The combination of being able to run DFM earlier in the process and easily working with a capable manufacturer allows the production of better new products, more quickly. For the manufacturer, design-executed DFM based on specific manufacturing requirements translates into fewer callbacks and higher yields.

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For more information, visit https://www.pcbflow.com

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