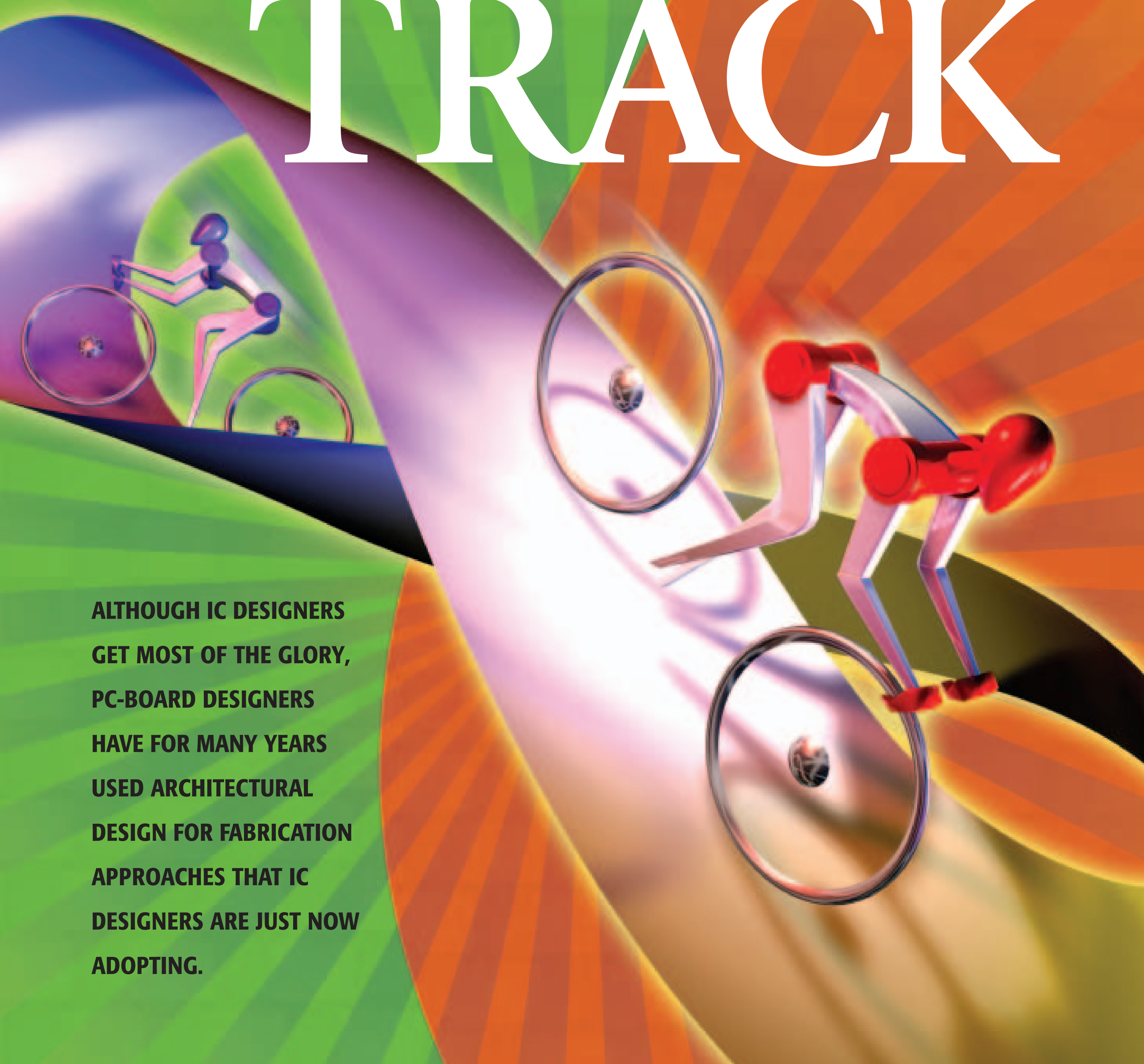
coverstory

On the same TRACK



ALTHOUGH IC DESIGNERS GET MOST OF THE GLORY, PC-BOARD DESIGNERS HAVE FOR MANY YEARS USED ARCHITECTURAL DESIGN FOR FABRICATION APPROACHES THAT IC DESIGNERS ARE JUST NOW ADOPTING.

THE DAC (Design Automation Conference) is the premier event of the EDA industry. It is the best opportunity for vendors to exhibit their products, for designers to obtain an overview of the latest technology, and for all industry participants to learn and discuss the most up-to-date design methods. During most of its existence, the DAC has focused on tools and methods for the development of ICs. You can find tools for pc-board design, but they are in the minority and take a back seat in the booths of vendors that provide both IC and pc-board tools. It would seem that IC-design methods and tools are leading the progress of EDA, and that pc-board design is a necessary but lowly function in the technological scheme of things.

By Gabe Moretti
Technical Editor

Illustration by Chuck Mackey

A less superficial look at electronic-system design shows that the opposite is true. Although IC designers are only now beginning to attempt architectural design, hierarchical-development methods, and DFM (design-for-manufacturing) approaches, pc-board designers have for some time used all three. IC designers are just now trying to imitate what pc-board designers have done for years. In designing a pc board, engineers choose verified functional blocks and connect them, respecting electrical- and electronic-design rules. When using discrete components, designers perform analog design, and issues of fabrication and testing are always at the forefront of a pc-board designer's mind.

Designers generally follow a four-step process in developing a pc-board: system design, system verification, layout, and production of fabrication data (**Figure 1**). Each step may involve a number of tools and disciplines. In particular, engineers have had to broaden the field of system verification to include such issues as signal integrity, high-speed design, power requirements and distribution, and RF design. Another area that requires attention is the design and layout of connectors and cables, especially when the pc board is a component of a larger system that involves transmitting data among various pc boards that share no common backplane.

System design involves drawing the schematic of the circuit. The schematic is not just the logical representation of a pc board; it also develops into its specification during the design process. Engineers enter the logical functions and connectivity of the design using computer-aided schematic editors. They also enter a number of properties for the packages, design rules that direct the router, and electrical rules that guide analysis engines. Design capture drives all other applications.

System verification allows engineers to verify that the choice of functions, connectivity, and the physical characteristics of both packages and traces meet the specifications. Designers use a number of tools in verification, depending on the problem they are solving. In general, engineers verify timing, signal integrity, electromagnetic interference, power, and thermal issues (**Figure 2**). During layout, engineers place and connect the packages and devices they instantiated in the schematic. The principal tool that accomplishes this task is a router, either in fully automatic or interactive mode. Generally, designers manually perform the most critical placement

and connections using an interactive router. Once they complete and verify this portion of the design, the automatic router handles the rest of the place-ment-and-routing function. Some cases require a final interactive session because the router cannot fully complete the board layout. Interactive placement and routing is an exacting and tedious process. The quality of the finished product is often a direct result of the experience of the engineer doing the layout. Once an engineer completes the board design, he or she must output various files and documents for manufacturing. A number of pc-board vendors provide tools that output the information in the required format.

AVAILABLE EDA TOOLS

The EDA market for pc-board applications has matured in the last few years through a number of mergers and acquisitions. Cadence and Mentor Graphics, respectively, have acquired long-standing vendors Orcad and Pads. Those acquisitions have allowed Cadence and Mentor to deploy a dual pricing structure that broadens their presence in the market and provides their customers with a wider choice of products. These two companies are responsible for about 75% of the yearly revenues. Zuken and Electronics Workbench have significant shares in segments of the market, and vie for third place in pc-board revenues.

The increasing importance of system verification has opened the pc-board market to companies that had previously focused only on IC design. Signal-integrity and thermal-analysis products are examples of this crossover. The rest of the vendors enjoy recognition in some segments of the market, and most of them have less than $10 million in yearly revenues. **Table 1** lists pc-board-tool vendors and the applications they serve. Although it is infeasible for this article to individually describe the tools, you can find all the information at the vendors' Web sites. Altium distributes tools under a number of brand names, including Protel, P-CAD, Nexar, and nVisage.

Wireless applications have in the last three years been the major drivers of the EDA market. Therefore, electromagnetic analysis has grown in importance. Agilent and Cadence lead this market. They derive their strength from their long-standing leadership in the IC-design market for the same type of applications. In April, Cadence announced its intention to purchase Neolinear Technology to further strengthen its technological portfolio in RF design. Agilent Eesoft plays a major role in the market for RF-IC design, and its leadership in that market allows it to be a significant player in the pc-board market, as well.

Most design-entry tools have similar functions, although higher priced tools understandably often provide more flexibility and support larger and more complex designs. You can say the same thing for place-and-route products, although Mentor Graphics seems to have an edge in this field. The main distinction among routers is the ability to fully support high-speed-design rules and analog design.

FPGA devices are getting faster in execution and growing in capacity. Designers are more frequently using these devices in pc-board design, because they are good replacements not just for glue logic but also for significant functional blocks that designers previously implemented with ASIC chips. Mentor is providing a system-design technology that allows engineers to concurrently develop both an FPGA and a pc board. FPGA BoardLink automates the placement and wiring of an FPGA symbol within a board schematic. It first generates the symbol with the appropriate pinout and retains the desired connectivity during any revision to either the pc board or the FPGA.

Connecting high-speed packages to a pc-board is also an increasingly complex problem. An improper electrical connection can generate signal-integrity and electromagnetic-interference problems. Large, multilayer boards; complex, multiterminal IC packages; and 3-D, on-chip passive structures are becoming common in high-performance designs. Common

AT A GLANCE

▷ PC-board designers have for years used a design method that IC designers are just now adopting.

▷ Although mergers and acquisitions have thinned the field, engineers still have choices in selecting pc-board-design tools.

▷ System verification is the most demanding stage in the design process.

▷ The major challenges facing pc-board designers are signal integrity, power consumption, and thermal radiation.

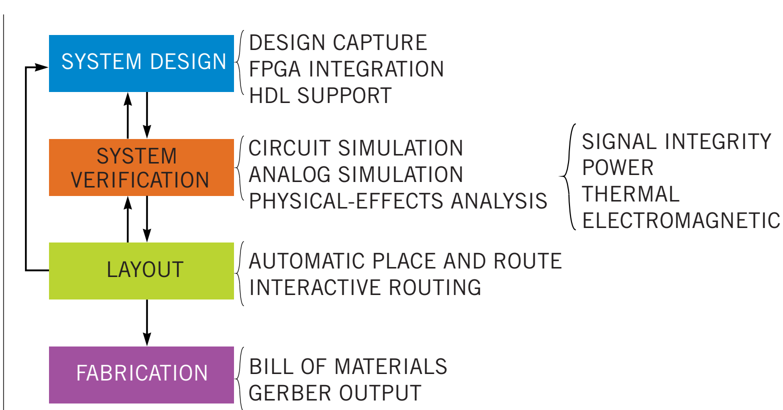


Figure 1 Designers follow a hierarchical method in developing a pc board.

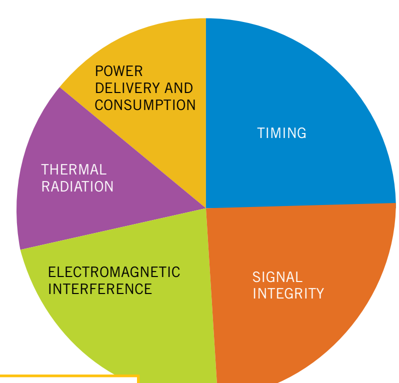


Figure 2 Most pc-board designers must deal with five major areas of system verification.

failure modes, including intersymbol interference and ground bounce, require electromagnetic analysis. In addition, engineers often perform frequency-domain power-integrity analysis, which they did not need a few years ago. Manufacturers of standard parts now deliver IBIS (I/O Buffer Information Specification) models as standard, whereas, just five years ago, it was rare to obtain an IBIS model with the technical information for a part.

In a high-speed-differential or source-synchronous design, the signals need to arrive at the receivers at the same time. Due to space limitations, most signal traces in a package have different lengths. Designers must compensate for these differences on the pc board. When, due to space limitations, a designer must route a signal around many bends and corners, the designer reduces the signal's

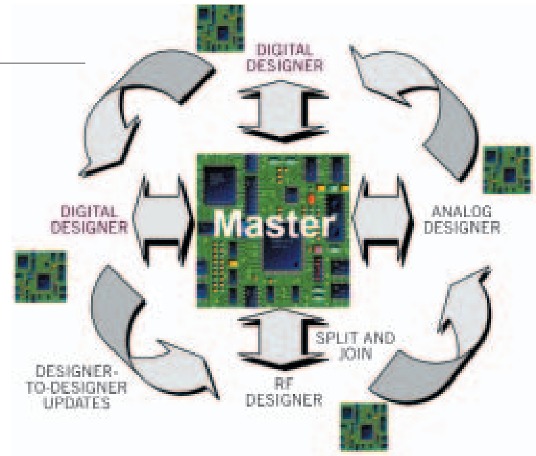


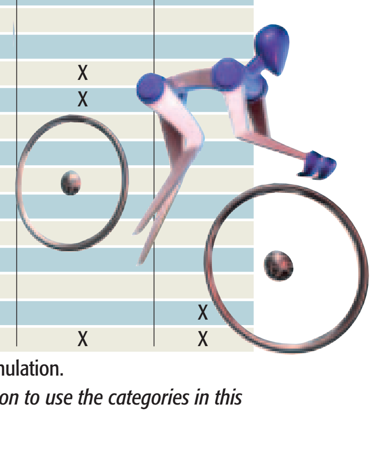
Figure 3 Team design allows concurrent design by both geographically dispersed engineers and engineers that specialize in an area of design.

TABLE 1—TOOL VENDORS AND APPLICATIONS

Company name	Web site	Phone	System design	System verification	PC-board layout	Fabrication	MCM, hybrid, and packaging	Cables, harnesses
Aavid	www.icepak.com	1-603-643-2600		TH				
Adiva	www.adiva.com	1-703-742-9400		SI		X		
Agilent	www.eesoft.tm.agilent.com	1-650-752-5000	X	EMI				
Altium	www.altium.com	1-858-485-4600	X	T, SI, EMI, CS	X	X		
Ansoft	www.ansoft.com	1-412-261-3200		T, CS, SI, EMI, P, MM, TH		X	X	
Applied Simulation Technology	www.apsimtech.com	1-800-955-0967		EMI, SI, P				
Applied Wave Research	www.appwave.com	1-310-726-3000		EMI, CS				
Beige Bag Software	www.beigebag.com	1-734-332-0487		CS				
Cadence Design Systems	www.cadence.com	1-800-746-6223	X	T, SI, EMI, P, MM, TH, CS	X	X	X	
Cadint	www.cadint.se	1-800-553-1177	X		X	X		
Cad-Migos	www.cadmigos.com	1-650-363-2813	X	CS	X	X		
ChipData	www.chipdata.com	1-214-615-8000	X					
Daat Research	www.daat.com	1-603-448-1302		TH				
Douglas Electronics	www.douglas.com	1-510-483-8770	X		X	X		
Electronics Workbench	www.electronicsworkbench.com	1-800-263-5552	X	SI, EMI, CS	X	X		
Flomerics	www.flomerics.com	1-508-357-2012		EMI, TH				
Integrated Engineering Software	www.integratedsoft.com	1-204-632-5636		EMI, TH				
Intercept Technology	www.intercept.com	1-404-352-0111	X		X	X	X	
Intusoft	www.intusoft.com	1-310-329-3295		CS, P				
Magsoft	www.magsoft-flux.com	1-518-271-1352		TH, EMI				
Mental Automation	www.mentala.com	1-425-641-2141	X	CS	X			
Mentor Graphics	www.mentor.com	1-800-547-3000	X	T, SI, EMI, P, TH, CS	X	X	X	X
Norlinvest Ltd	www.norlinvest.se	+46 8 792 2620	X	EMI, TH, CS	X	X		
Number One Systems	www.numberone.com	1-503-251-0796	X	CS	X			
OEA International	www.oea.com	1-408-778-6747		SI, P				
Ohio Design Automation	www.ohio-da.com	1-603-598-2525	X			X		
Optem Engineering	www.optem.com	1-403-289-0499		EMI, SI			X	
Optimal Corp	www.optimalcorp.com	1-408-363-6300		SI			X	
Penzar Development	www.penzar.com	1-818-347-9203		CS				
Precience	www.precience.com	1-301-421-9054	X					
Quantic EMC	www.quantic-emc.com	1-204-942-4000		SI, EMI, MM				
Sigrity	www.sigrity.com	1-408-260-9344		EMI, SI, CS, P				
Spectrasoft	www.emisoftware.com	1-310-371-3903		EMI				
Spectrum Software	www.spectrum-soft.com	1-408-738-4387		CS				
Thermoanalytics	www.thermoanalytics.com	1-906-482-9560		TH				
TurboTools	www.turbotools.com	1-415-759-5599						X
Zuken	www.zuken.com	1-800-356-8352	X	SI, EMI, TH		X	X	X

T=timing, SI=signal integrity, EMI=electromagnetic interference, P=power, MM=metal migration, TH=thermal, and CS=circuit simulation.

Thanks to Gary Smith, Daya Nadamuni, Laurie Balch, and Nancy Wu at Gartner Dataquest, who developed and gave permission to use the categories in this table.



propagation delay and must compensate for this reduction by lengthening the trace. In a 90° bend, for example, the signal can "cut the corner" and speed up by 0.1 to 0.5 psec per corner. Although metal-migration problems are more prevalent within an IC, poor mechanical connectivity between a pc board and the pins of a package can also suffer from this problem.

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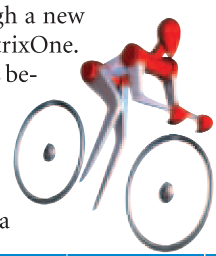
Engineers and analysts talking about team design often mean different things. Some are describing a method to divide a project among a number of engineers and keep the work concurrent and synchronous (**Figure 3**), whereas others are describing PLM (product-life-management) tools (**Figure 4**). TeamPCB from Mentor enables a team to design a board in parallel. An engineer, normally the project leader, divides the design into sections, with each designer working on his or her section but with the ability to view the entire board. Although the project leader can divide the board according to functional areas, such as digital, analog, power, and so on, he or she can also divide these sections among designers. Engineers can share progress using automated database updating on a designer-to-designer basis, or they can use their progress to update the master database. The method works well when a company outsources portions of the design or has a geographically dispersed team.

Cadence supports the other concept of "team design" through a new partnership with MatrixOne. As electronics systems become more complex, the need for partnering grows. Companies can in many cases no longer develop a system from beginning to end. They need to partner with other companies that specialize in a portion of the design or manufacturing process. Yet, the complexity of the project requires sophisticated project-management tools. Cadence is beginning its support of PLM by implementing the pc-board portion of the support chain but plans to support the entire electronics subsystem. Along with Cadence, Flomerics, Ohio-DA, and Zuken are offering team-design support.



As electronics systems become more complex and more distributed, engineers achieve connectivity among pc boards not just with a backplane, but also by using both parallel and high-speed serial connection through wires. The ability to develop cables and harnesses by synthesizing their components from the I/O description of two subsystems is becoming more important. Mentor has for some time held the lead in this market, but both Zuken and start-up TurboTools offer competitive products. TurboTools has just completed an agreement with the national distributor of Orcad products, and its product, CablEquity, is available through EMA Design Automation (www.ema-eda.com).

The pc-board-application area is dealing with the same type of problems that digital-IC designers face, but the need to deal with analog design as well as the inherent hierarchical nature of pc-board design increases this complexity. IC designers need to look at the methods pc-board design uses to increase the quality of their DFM designs.□

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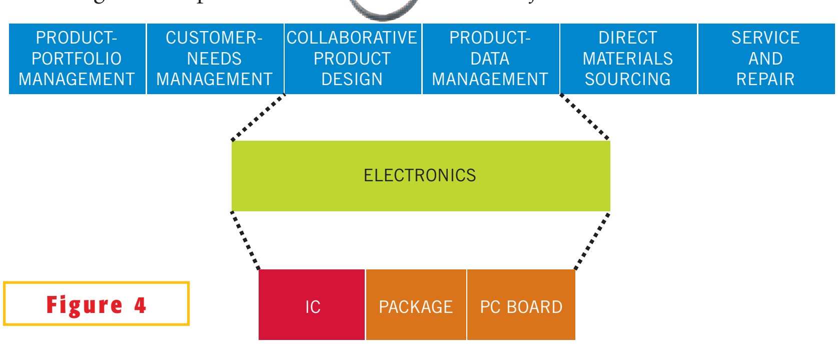

Figure 4

Electronics-design-data management is a subset of the part-life-cycle-management continuum.