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The Growing Popularity of In-House PCB Prototyping

by Stephan Schmidt -- 12/1/2004
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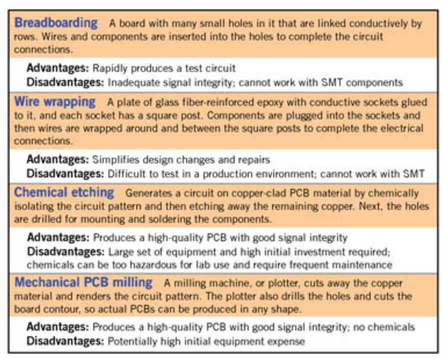
Today, more than ever, prototyping is crucial to the electronic design process. In this world of blazing time-to-market requirements and fierce R&D expectations, effective prototyping is critical to success. Yet, in spite of the need for effective prototyping, engineers still find themselves constrained by the time and cost limitations inherent in outsourcing their prototypes. As a result, an increasing number of engineers are adopting in-house prototyping because of its enhanced technological capabilities and clear advantages over outsourcing.

The following example is typical of the time and iteration constraints inherent in outsourcing. An engineer must order a minimum of 10 to 20 boards and wait one to two weeks in order to receive an initial prototype. Usually, the prototype is populated with components and then tested. If the test results are unfavorable or the engineer wants to test a second iteration, then the design has to be reconfigured and a set of prototypes created a second time, usually taking another one to two weeks to be received and tested. Since effective prototyping almost always requires multiple design iterations, outsourcing makes it difficult to meet the demands of many development cycles. Plus, downtime between prototype builds can lead to a loss of engineering focus and momentum, thus causing projects to suffer.

Another problem with outsourcing is that the cost to fabricate one or multiple prototypes can be prohibitively high and these costs must be estimated for each project. Outsourcing costs become an even greater issue when designing multilayer boards. Those costs can easily run into the thousands of dollars for a single prototype.

In-House Prototyping Methods

Engineers have several production methods available for fabricating prototype boards and test circuits in-house, depending on the type of circuit and its application. These methods are described in the following chart:



Breadboarding A board with many small holes in it that are linked conductively by rows. Wires and components are inserted into the holes to complete the circuit connections.

Advantages: Rapidly produces a test circuit
Disadvantages: Inadequate signal integrity; cannot work with SMT components

Wire wrapping A plate of glass fiber-reinforced epoxy with conductive sockets glued to it, and each socket has a square post. Components are plugged into the sockets and then wires are wrapped around and between the square posts to complete the electrical connections.

Advantages: Simplifies design changes and repairs
Disadvantages: Difficult to test in a production environment; cannot work with SMT

Chemical etching Generates a circuit on copper-clad PCB material by chemically isolating the circuit pattern and then etching away the remaining copper. Next, the holes are drilled for mounting and soldering the components.

Advantages: Produces a high-quality PCB with good signal integrity
Disadvantages: Large set of equipment and high initial investment required; chemicals can be too hazardous for lab use and require frequent maintenance

Mechanical PCB milling A milling machine, or plotter, cuts away the copper material and renders the circuit pattern. The plotter also drills the holes and cuts the board contour, so actual PCBs can be produced in any shape.

Advantages: Produces a high-quality PCB with good signal integrity; no chemicals
Disadvantages: Potentially high initial equipment expense

In-house prototyping methods. (click image to enlarge)

Breadboarding and wire wrapping methods are low-cost, but they do not provide the high signal quality and compatibility with SMT components often required by today's complex designs.

Chemical etching can produce prototype boards that are comparable in quality and performance to outsourced boards. However, the financial impact of implementing chemical etching is reflected in the large quantity of equipment that must be purchased. The etching chemicals can also be hazardous and require frequent maintenance, thus requiring the equipment and chemicals to be monitored even when they are not in use.

Mechanical PCB milling systems (also referred to as plotters) produce high-performance boards that match the quality of outsourced PCBs by delivering high signal integrity and SMT component capability. Producing milled boards in-house does involve an initial investment in equipment and materials, but the long lifespan of this equipment means that the cost can be amortized over five to 10 years. Plus, milling machines do not require hazardous chemicals for processing, so their maintenance is much less involved than it is for chemical etching and environmental certificates and permits are not required.

Mechanical PCB Milling Prototyping

The area of in-house prototyping that is experiencing significant growth is the PCB milling and related equipment market. Many users of this equipment are former outsourcers who benefit from the increased productivity, performance and control this equipment provides. Maintaining total control over prototyping projects while still producing boards equal to outsourcing is an important factor in its continuing adoption.

Mechanical PCB prototyping never requires a minimum production quantity. Design engineers can fabricate one or many boards simultaneously, all of which can be tested and reconfigured the same day. This instant turnaround enables designers to make immediate revisions one at a time instead of being forced to accumulate design changes. Plus, fabrication and testing time is reduced from weeks to minutes. This encourages better designs and fewer production-related mistakes. Concerns about guarding a design's intellectual property are also alleviated because development efforts remain in-house.

Mechanically milled circuit boards.

Advances in PCB Milling Technology

Recent advances in PCB prototyping and milling system technology continues to be a primary factor contributing to the growth of this technology. Unlike earlier, basic milling equipment, the newest systems are easy to operate and have the precision to fabricate multilayer PCBs that use cutting-edge SMT components and have professionally-plated through-holes. The milling precision, reliability and operating convenience delivered by today's state-of-the-art PCB plotters offer engineers a rich set of prototyping tools. Capabilities such as automatic front-to-back alignment, automatic tool change and automatic milling depth adjustment enable these systems to operate unattended. Hybrid systems combine the milling, drilling and contour routing capabilities of a PCB plotter with the fine structuring ability of a laser system. Integrated CAM software drives these systems and provides the tools for defining the board production process. In addition, the system software allows engineers to work directly with their own PCB production CAD data, giving them insight into ways to improve their designs.

For designs involving complex RF and microwave boards, the latest PCB plotters can mill these types of circuits on a variety of substrates, from standard FR4 to PTFE-based material. Non-contact milling techniques ensure that the substrate is precisely cut and delicately handled to preserve the design's performance characteristics.

LPKF ProtoMat® H100 PCB plotter.

Other in-house prototyping equipment used in conjunction with PCB plotters now give engineers the ability to fabricate prototypes with up to eight layers. Compact PCB laminating equipment securely bonds the inner and outer layers of multilayer boards, while in-house electroplating tools can plate very small through-holes with the quality and reliability of an outside circuit board fabrication facility. Protective solder masks can now be applied in-house, and SMT assembly equipment automates the precise placement of surface-mounted components on the finished PCB.

Their ability to produce prototypes, multilayers and test circuits that are equal to outsourced boards, combined with their time and cost advantages over outsourcing, makes in-house PCB milling technology and related equipment a viable alternative for every engineer looking for more from their prototyping efforts.

About the author

Stephan Schmidt graduated in 1994 from Hannover Technical College in Germany with a degree in Electronic Test and Measurement.

He joined LPKF Laser & Electronics in 1984. In 1994, he became involved with international technical sales for rapid PCB prototyping systems, focusing on RF and microwave applications. Since 1999, he is the General Manager of LPKF Laser & Electronics North America in Wilsonville, Oregon. He can be reached at (503) 454-4202 or sschmidt@lpkfusa.com.

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