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, sourcing 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:

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breadboarding</td>
<td>Provides 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.</td>
<td>Mechanical PCB milling systems (also referred to as plotters) provide 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.</td>
</tr>
<tr>
<td>Wire wrapping</td>
<td>Simplifies design changes and repairs</td>
<td>Requires high-quality PCBs with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produces a high-quality PCB with high signal integrity. Produ...</td>
</tr>
</tbody>
</table>
about guarding a design's intellectual property are also alleviated because development efforts remain in-house.

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.

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.