U

ADVANCED
ASSEMBLY

USE SPRING LOADED TEST PINS IN YOUR NEXT DESIGN

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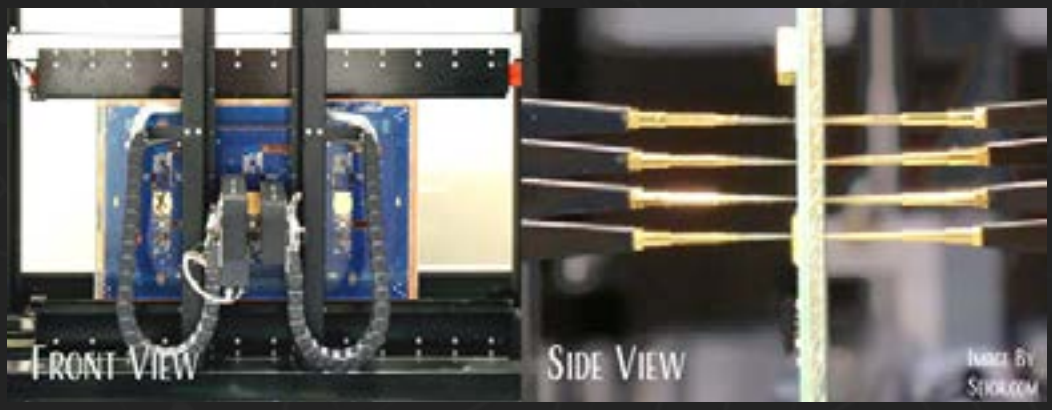
When you scale your design up from prototype to production volumes, the time needed to test and program each board scales linearly with production.

Whether you make 10 boards or 10,000 boards, it often makes sense to design and prototype a small test fixture to avoid a production and programming bottleneck. This article introduces both fixtured and fixtureless test apparatus used in small and large scale printed circuit board manufacturing.

FIXTURELESS TEST APPARATUS

If you have been in the industry for any length of time, you are likely aware of the flying-probe test apparatus.

Flying probe machines have spring-loaded test pins that can quickly move to each and every exposed conducting surface on both sides of an unassembled printed circuit board. While in contact with multiple conductors, the machine checks for open-circuits within the same net, or short circuits between different nets using spring-loaded test probes.



This front view and side view of a flying-probe test machine show the multiple probes used to create electrical connections with a printed circuit board.

Once a circuit board is assembled, the solder pads become inaccessible on leadless parts (BGA, QFN, etc…) since they are covered by the part body, so flying probe conductivity tests often only take place before assembly. This machine can be programmed to test almost any board for open & short-circuit faults -- and while it is fast, it still does take several minutes per board per test -- so it is ideal for prototype and short-volume runs.

FIXTURED TEST APPARATUS

If you have between a few dozen and several hundred thousand boards to test and program, it likely makes sense to design and build a custom test fixture. These fixtures can range anywhere in size from a small desktop machine the size of a toaster, to large enough to accept entire panels at once. And they can perform basic tests and measurements, or they can be designed to program and debug as well. The circuit boards that are used in the test apparatus are often only ever produced in small quantities, but they can have a tremendous impact on the throughput of a production line.

If you are going to use a test-fixture, you need to design your board to work with it. Test probes are small -- but they need enough space around them to prevent short-circuits and allow extra space around the probe to provide mechanical support.

Image of test fixture courtesy http://www.ett.bme.hu/meca/Courses/AIT/8_3.html

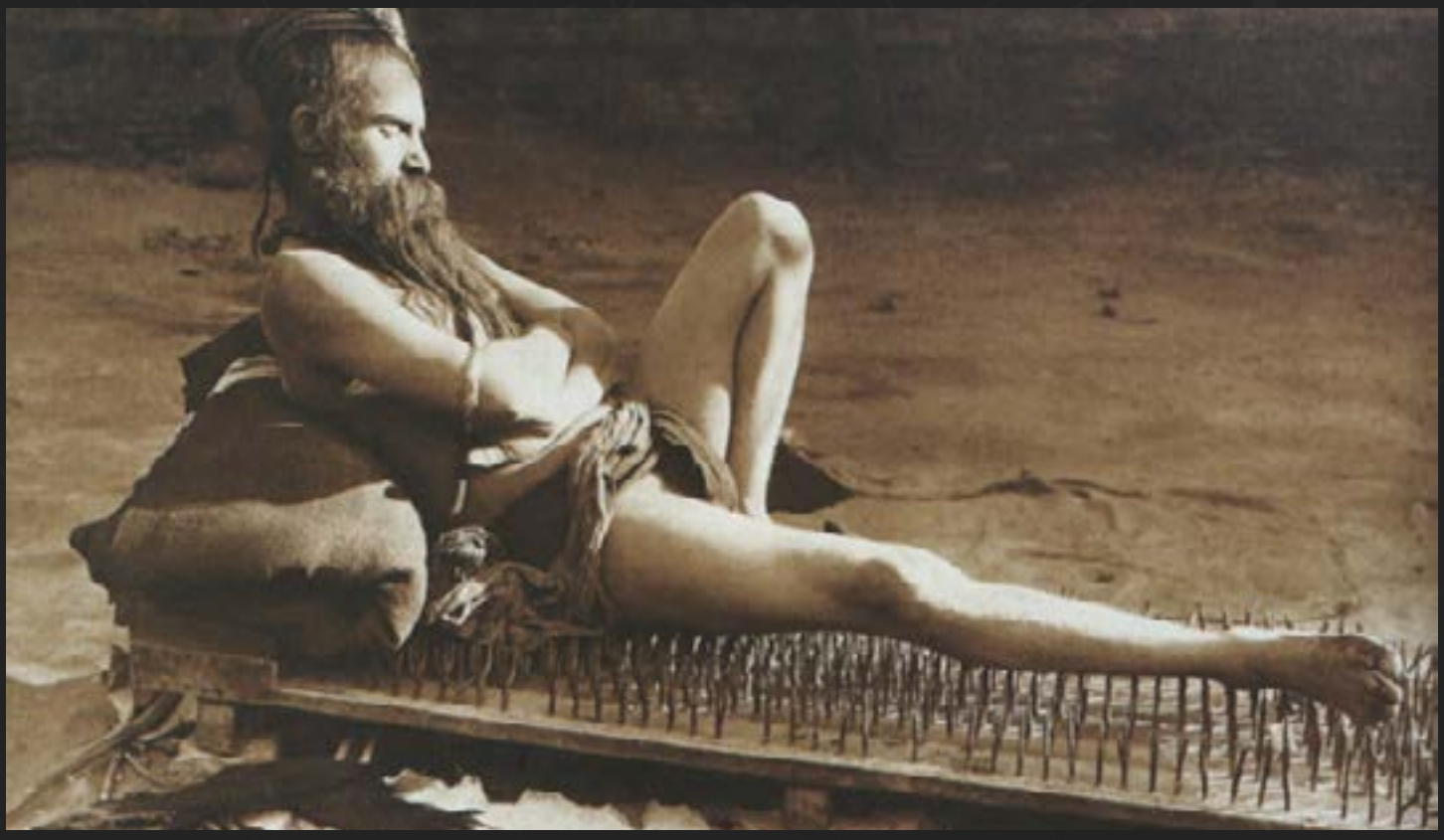
If you plan to perform in-circuit testing, programming and debugging, you will need to design test-pads in your PCB. While you can place pads on both sides of a board, it is easier to design a test fixture that has probes on a single side of a PCB.

Image of test fixture courtesy http://www.ett.bme.hu/meca/Courses/AIT/8_3.html

Even if the spring force below each probe provided less than 1 N of force, with dozens or even hundreds of test probes in use at once, the downward force required can be quite substantial. Pneumatic, vacuum, or mechanical presses are often installed to provide the needed force. It is not sufficient to clamp large PCBs only at their edges, force must be distributed over the entire surface of the board.

As a side-note, you might have heard of test-fixtures described as a "Bed-of-Nails." This is an homage to the carnival attraction that has performers lie on a board that has hundreds of nails protruding from the surface.

Adding unfilled vias to a thermal pad can cause issues as well. Not only does the via allow solder thieving, but it can also allow outgassing into the space between the part and the PCB, forcing solder away from the thermal pad.



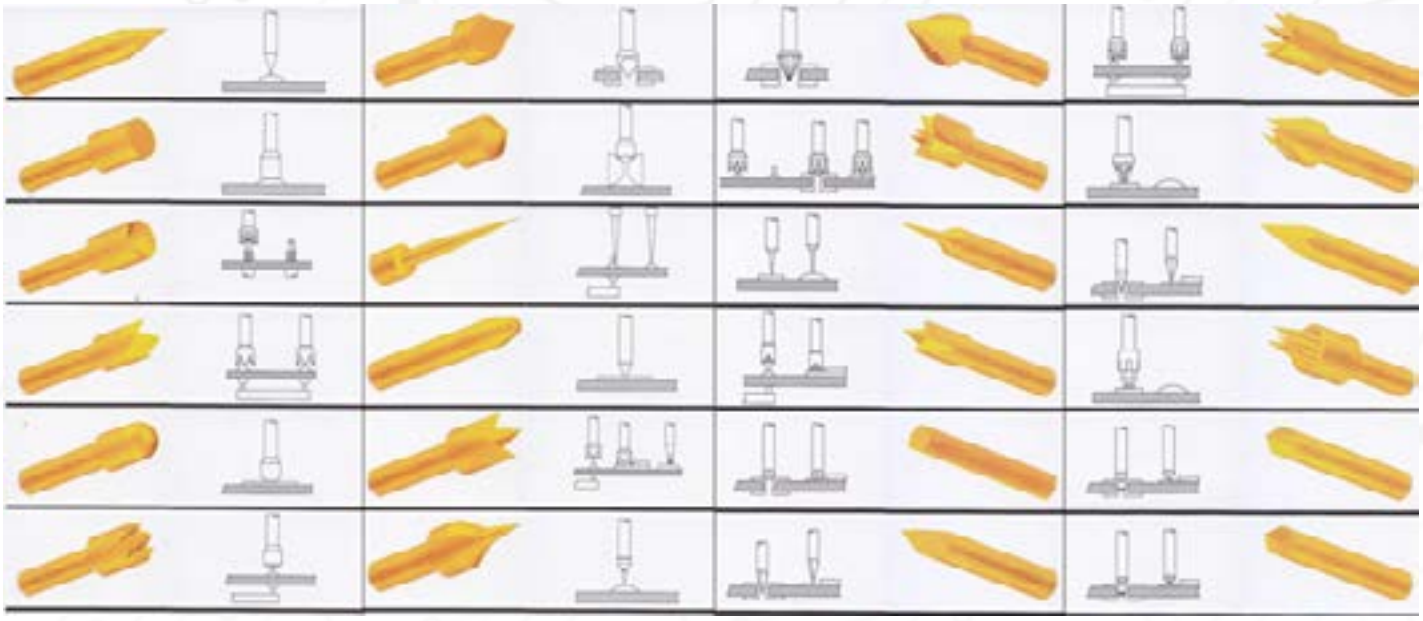
Herbert Ponting's 1907 photograph of "a fakir in Benares" (Varanasi, India) from Wikipedia.com

TEST PROBES

There are a wide assortment of test probes available for your next design, including coaxial probes for high-speed and RF signals.

This image of various spring-loaded probe tips is from https://www.peaktest.co.uk/

But how do you select the right probe for your next design? There are several factors to consider -- but the two biggest are surface finish and surface geometry.



Select head designs from bukalapak.com

Surface Finish Considerations for Pads

For Electroless Nickel Immersion Gold (ENIG) and Electroless Nickel Electroless Platinum Immersion Gold (ENEPIG) surface finishes, a flat or rounded tip probe will likely provide adequate electrical connection without damaging the surface finish. That is because gold the gold atoms on the surface do not oxidize. But Hot Air Solder Level (HASL), bare-copper, and OSP Finishes usually require a single or multi-point sharp probe head to penetrate surface contaminants and oxidation layers.

Surface Geometry for Solder Connections

Solder oxidizes over time, so sharp single or multi-point test probes are needed to push through the oxide layers to reach the solder metal below. If you are probing an SMT solder filet, a sharp, narrow probe should be selected. If you are probing a through-hole part, a waffle head might be useful.

Pins, Headers, and Screws

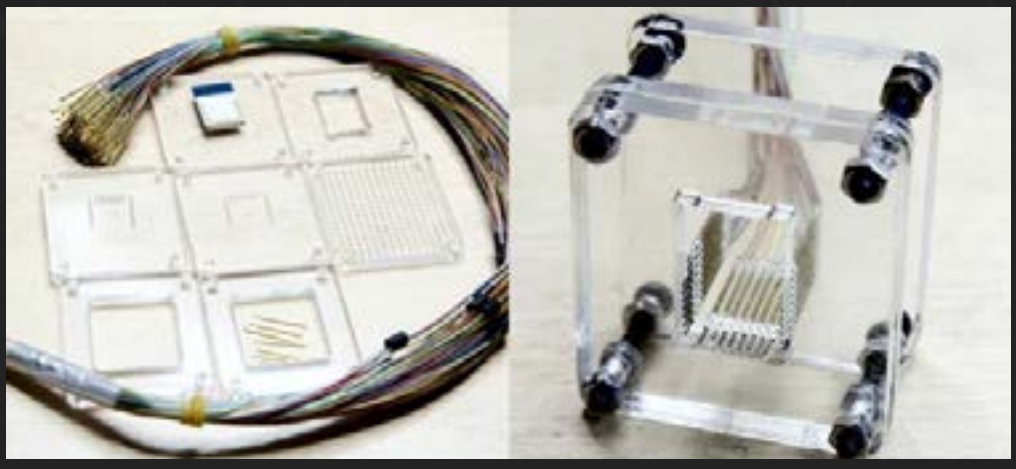
Concave tips can be used to contact vertical pins, and waffle-headed pins can contact screws.

SMALL-SCALE USE

Even if you don't want to make an entire bed-of-nails for your next project, that doesn't mean that spring-loaded probes cannot still be useful.

Module Programmer

The cost of FCC certification is several thousand dollars. For small projects, it often makes sense to purchase pre-certified wireless communication modules. But before those modules are soldered into place on a parent circuit board, they should be programmed and tested. A small homemade test-fixture that uses spring-loaded pins to connect to the castellated vias might work well in that use-case.



This home-built laser-cut test fixture was designed to hold a small Bluetooth module for programming and testing prior to installation in a larger circuit board.

If cutting and designing your own text fixture seems to be too much work, there are open-source projects such as OpenFixture (https://github.com/tinylabs/openfixture).

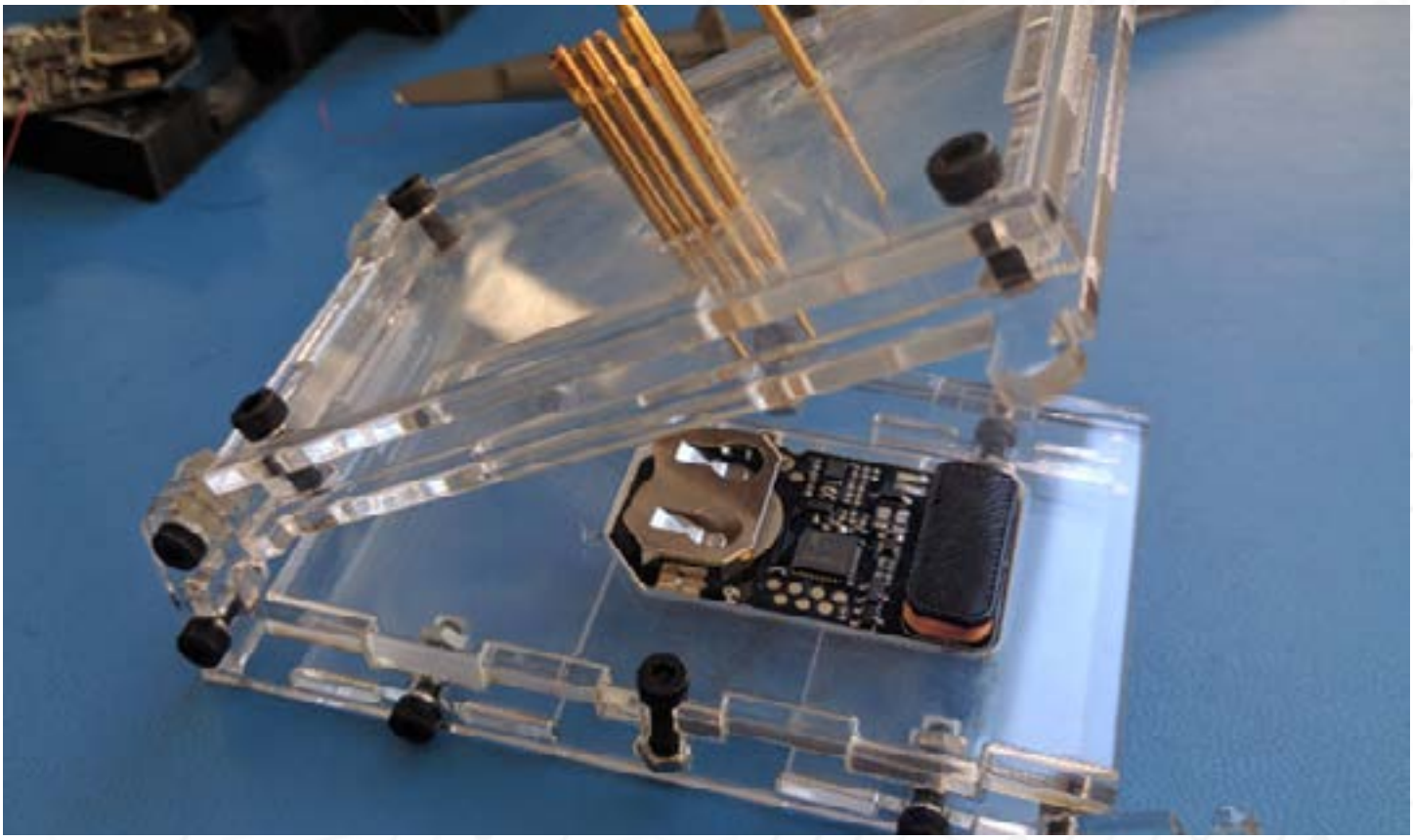


Image of parametrically generated pogo-pin test fixture from https://github.com/tinylabs/openfixture

SPRING-LOADED PROGRAMMING/DEBUGGING

Tag-Connect.com sells spring-loaded programming cables that are designed to fit a particular printed circuit board footprint. Engineers buy the programming cable once, and then add the zero-cost footprint to all of their designs. The programmer can be used to program as many boards as needed. The advantage of this technique is that allows designers to remove the programming header from their PCBs -- the footprint can be added to a PCB for no-additional cost.

This set of images from tag-connect.com shows the head of the programming cable, the footprint, and the two devices connected.

SUMMARY

Spring-loaded test pins have been around for 40 years. If you need to test more than one or two dozen PCBs, it likely makes sense to design your own test and measurement fixture. If you are measuring high-speed signals, it might even make sense to characterize your test-fixture so you can subtract the s-parameters of the fixture from your device under test.
