The Misunderstood Myth about Fixtureless Probers

By Jim Axton of Test Connections, Inc.

The 2001 printed circuit board industry slow down resulted in many PCB fabricators turning to flying probes as their electrical test solution for their products. Production lot quantities decreased, along with pricing, and many board buyers would not “pay for test”. Meaning they would not provide purchase orders for test tooling (i.e. test fixtures).

PCB designs continued in their ongoing complexity. These complex designs strained every aspect of printed circuit fabrication from the FTP site through CAM, DES, etc. All areas of manufacturing under went radical changes, but electrical test (ET) was strained more than most areas. Simply, because panels became individual circuits, each unique circuit (part number) required an individual test tool and the test tools were not adequate to meet the challenge.

During the boom years, 1998 through 2000, few North American PCB fabricators invested in new universal grid test systems (UGT), fewer purchased double density test grids, most did not invest in state of the art test fixture software, and only one major US PCB Fabricator standardized their UGT test fixture format for all test systems for all fab sites. In North America and Europe during the last five years the PCB shops have elected to migrate to flying probes. Why? Was it a conscious decision?

We believe it was intellectual lethargy, and with a personal history of 50,000 plus successful test fixtures, we have the facts to back it up. The uncontrolled drifting to flying –probe-test-***ONLY*** department has unwittingly put some PCB fabricators in the wrong direction, technically and financially.

First, in developing the perfect electrical center, there are essential tools required.

1. ATE Software
    a) A Test CAM package capable of reading in IPC-D-356x net lists and performing CAD to Gerber (RS-274X or ODB++) checks.
    b) This Test CAM suite must also extract compliant IPC-D-356x net lists and trace data for your UGT & flying probe testers.
    c) This Test CAM suite or a second stand alone test fixture CAM package that will generate test fixture files (Excellon drill, test, verification, & repair), and flying prober combinational files (i.e. oversized boards, unique features, etc.).
2. Universal Grid Testers (UGT)
    a) At a minimum .100 inch grid top & bottom
    b) If business & finances dictate, a 2nd UGT with .071 inch grid (double density)
3. Flying Prober
    a) Must be capable of minimum pitch of .003 inches
    b) A minimum feature of .002 inches
    c) Some type of UGT to Flying Probe verification software for auto verification
    d) Capable of soft touch or landing for wire bondable product

e) High Voltage capabilities (at least 1000 vdc) for automated hipot
f) Capable of testing multiple Z axis – Cavity product

4. Verification & Repair Software
   a) Must be compatible with all of your existing UGT & Probe testers
   b) Accept fault data via barcode & via network
   c) Must be IPC-D-356x compliant
   d) Performs data collection (i.e. number of opens, shorts, by part number)

The combination of a great test fixture and a flying probe are the most powerful tools in your test arsenal.

The Cost of Flying Probe Test versus Test Fixtures

There is a common assumption that flying probe test is less expensive that using your universal grid tester. This myth evolved for two reasons, the companies selling flying probes promoted this tale, and most PCB fab shops built ineffective test fixtures that performed poorly at critical times just before FedEx was due to arrive.

As we mentioned earlier, most PCB shops were not investing in test fixture technology over the last decade, and the new designs with microBGAs quickly showed how fragile the old test fixture formats were. It was easier to put these complex PCBs on the flying probes than revamp and upgrade the test cam department. Besides, business was down and the number of new part numbers was insignificant. Everyone became complacent.

Not everyone in the PCB industry saw it that way. First, you must understand the history and “mechanics” of the flying probe. The flying probe was originally developed as a tool for testing unique features and products. Wire bondable gold where witness marks or bond pad damage was unacceptable was an early application. Ceramic based (co-fired) PCBs could not be placed on a bed of nails (test fixture) or they would fracture. Small PCBs with cavities (wire bond sites on multiple Z axis) were untestable until flying probes came along.

Flying probes, no matter how many test heads they have, are serial or sequential testers. Simply, when they perform the leakage test (shorts), they have to test each net in sequence. The standard equation for shorts testing is;

N^2 -1 (Number of Nets Squared -1)

750 nets^2 - 1 = 562,499 leakage tests

UGT’s and dedicated units are parallel testers, meaning they can test many nets for shorts in parallel (at the same time). Simply, UGT’s are very fast at performing the leakage test.

To compensate for the lengthy leakage test, flying probe manufacturers have developed software and electronic shortcuts to truncate the extended test times. Phase, field

measurements, and capacitance are all buzz words for the probe vendors when they are making this type of measurements. Just a quick note; the mil-spec does not recognize these passive leakage tests, only true resistance style measurements.

One last topic on flying probes before we get to real test costs; there is a little secret all flying probe vendors do not discuss when they are promoting their systems. The big cost savings with flying probes is supposedly the lack of test fixtures and the time you save. Yet, every new part number must go through a self-learn cycle on the flying probe for phase (capacitance, field effect, etc.). This self-learn cycle will be two to three times longer than the actual test times and must be performed on each flying probe that is utilized for that part number. Guess what, the next time you test that part number you will go through the self-learn cycle all over again. The self-learn times are dependent upon the number of test points, number of nets, (with some systems, the number the of 2 node nets), and the basic capacitance of your product. Your probe vendor will tell you that the system stores the "buzz word" file. Unfortunately, the PCB fabrication process is such that the board capacitance changes lot to lot, rendering this feature useless. Probe vendors have been attempting to capture this learned capacitance from the first probe and transfer to the secondary probes. So far they have been unsuccessful. We believe it is not cost effective for the probe vendor, so this feature may be along later, if at all

In the North American PCB industry today, the business segment is high technology, military, government, quick turn, and pre-production. So, this means for most PCB shops, more part numbers and smaller lots sizes. Test Fixtures can be cost effective for small lots, even very small lots. The real issue is time, not lot size. How many test lots can you effectively get through your ET department in a day? If in 2000, you were shipping 10 to 12 jobs (part numbers) a day, you will probably have to ship 15 to 18 just to meet the same revenues in 2004, if not more. Along with the additional shipments, the average number of test points per board has risen by 25 percent. In some cases, the technology has driven the product to extremes. We now see PCB with 40,000 test points + as an every day occurrence. Five years ago, these types of product were unusual.

We interviewed many PCB shops in North America over the last three months about their electrical test issues. The responses were similar regardless of the regional location or market segment. The average number of test points had climbed to almost 4,000. Yet the PCB sizes had scaled down, more per panel, and more test points per square inch. As mentioned in the paragraph above, the prototype/quick turn shops were averaging 18 to 20 new part numbers in test. The average lot size was 25 to 30 pieces. Almost everyone was having problems with 0.5mm BGAs.

Our question to you is how many flying probes would you need just to handle just 15 new part numbers per day?

Assumption: 3,500 test points with 750 nets.
Using the average test times we collected and 25 piece lot sizes.
Test times include placing the board on & off the probe

Learn time: 20 minutes
Test time per board: 6 minutes
Total Test Time Lot: 6 x 25 150 minutes
Total Flying Probe Time: 170 minutes
Now expanding on that assumption (we all understand that all boards are not the same)

15 production lots to be flying probe ET times 170 minutes **1,926.67 minutes or 32.11 hours**. This was based on one flying probe working non stop. We did not include setup or debug times.

Assumption: 3500 test points with 750 nets.
On a universal grid tester with our Quick Fix test fixture
Test times include load & unload of PCB

Learn time: 0 minutes
Debug / check for missing pins 10 minutes
Test time per board: 40 seconds
Total Test Time Lot: 40 seconds x 25 17 minutes
Total UGT Test Time: 27 minutes

15 production lots times 30 minutes 7.5 hours

The real issue is productivity, time, and the amount of product you can move through the electrical test department each shift, each day. By the way, the answer is **2 flying probes** for each **15 NEW** jobs per day. We did not discuss repeat or ongoing production work. As the number of test points goes up so do the test times on flying probes.

You can run the same exercise with shop hourly rates:

Each PCB fabricator has an hourly rate for the production floor that is one of the factors used by their sales group in quotes on new PCB part numbers to their customers.

15 production lots per day on two flying probes will take 32.11 test hours @ $75/ hour equals $2400.00

15 production lots per day on one UGT tester will take 7.5 hours @ $75/ hour equals 562.50

Remember that the cost of test must be added to each individual PCB that shipped in order to capture the true cost of test.

$ 2,400 (Cost of flying probe test 32.11 hours) equals $ 6.40 per PCB
15 production lots X 25 pieces /lot

$562.50 (Cost of UGT test 7.5 hours) Equals $1.50 per PCB
15 production lots X 25 pieces /lot

Lastly, test fixtures can be timely, reliable, and cost effective. As mentioned earlier, even for prototypes and small quantities, a reliable test fixture can out perform a flying probe when time counts.

Test fixtures can be designed, drilled, and assembled in parallel with the PCB fabrication. Depending on your drill equipment, shop hourly rate, and test fixture materials, your test fixture fabrication costs can run from as little as $.05 per test point. Using exotic materials (FR-4, CM-1, etc.) will drive the costs up more than any other factor.

Once again, we believe the best electrical test center has universal test grids and flying probes as this provides flexibility and cost effective test methods.