As originally published in the IPC APEX EXPO Proceedings.

Effective Test-Probe Assignment on PCB Electrical Testing

Takeo Negishi
Gardien Japan Co., Ltd
2-4-3 Takanodai Nerima Tokyo 177-0033, JAPAN

THE IMPORTANCE OF TEST POINT OPTIMIZATION

Test point optimization for the PCB electrical test domain brings the test speed faster for the flying probe tester (FPT), and the fixture cost lower for the fixture type tester. The importance of optimization is increasing along with the shrink of PCB design rule, especially for the fixture type testing.

There are 2 types of test point optimization:

1. Probe position optimization (position optimization of the probe contact point in the test pad for the larger margin). The optimization reduces the probe contact failure for the FPT and fixture, so that the pass rate increases.

2. Probe type optimization for the fixture type test (selection of optimum probe type such as size and head shape). In general, the smaller the probe diameter, the higher the probe pin cost. So the cost of fixture can be reduced by selecting the larger diameter probe pins.

POSITION OF TEST CONTACT POINT AND SELECTION OF TESTING PROBE TYPE

The PCB design is made as close as the CAD design. However the real PCB is not 100% same as CAD design, since there are the production related errors such as the material shrink/expansion, the pattern shift/distortion, the error by drilling accuracy, etc. The testing machines also could be the source of the position error. For the case of FPT, the limitation of mechanical positioning accuracy could cause the probe positioning error. For the case of the fixture, the limitation of positioning accuracy by the drill machine could cause the probe position error. So the position of test contact point in the pad is important to improve the test productivity for the electrical test.

In general, the probe position for test is better to be the center of test pad on a PCB to avoid the errors from the PCB, the test equipment and fixture, since it gives the largest deviation for such positioning errors between the probe and pad. And it reduces the chance of retry due to the less probe contact error, thus higher productivity of test.

(A) Probe position for the FPT

As the result, the position of the test contact point is at the center of test pad (Fig.1-a) for the test by the FPT.

(B) Probe position for the fixture type tester such as the dedicated tester or/and the grid tester

Now, for the case of fixture type testing, the positioning logic becomes more complicated as described in below.

Ideally, it is better to position the probe at the center of the test pad, but as both the probe cost and drill cost increases by decreasing the probe diameter, the fixture manufacturing team prefers to use the probe diameter as large as possible. However if we use larger diameter probe, it become difficult to maintain the necessary clearance among the probe pins, especially for the design like QFP pad. If there is not enough clearance even off center the contact point from the pad, then the CAM engineer in the fixture manufacturing team selects the smaller diameter probe pins to gain the enough clearance among the pins.

In the example of Figure 1, where we consider X axis as the horizontal direction and Y axis as the vertical direction, each test pad size is X=2.0mm, Y=0.2mm and multiple pads are located Y direction by the same center-center distance of 0.5mm. Assume 0.3mm as the clearance min limit of pin surface – surface distance for the 0.6mm diameter probe pin for a fixture. If we position the test contact point at the center of the pad (refer Fig.1-a), there are not enough Y direction clearance (i.e. 0.6mm pins could physically touch each other and cause the electrical shorts). So we cannot finish the CAM job by this design.

In contrast, if we position the probe contact point by stagger, such as the bottom point right, 2nd bottom point left, 3rd bottom point right, and so on (refer Fig.1-b), then the clearance distance is now between the probe pins of odd pad or even pad, respectively. And thus the clearance distance become 1mm and enough to pass the clearance limit in the example, so that we can use this 0.6mm probe pin, which gives lower cost than the 0.4mm or smaller pin.

In general, this stagger process is automatically done by CAM software or/and the fixture design software. Now, many of the commercial software move the position at the pre-defined constant distance from the pad edge (refer Fig.1-b) for the entire PCB design. The purpose to set the constant distance from edge is to give the positioning margins from the pad edge, even using the larger diameter pins (note: larger diameter pins generally requires larger positioning margin).

And that software selects the smaller diameter pins, in case there is not enough clearance at the position which is set by such constant distance. So the constant distance cannot be large, but needs to be as small as possible. Or the cost of pin and drill job increases.

However, in the real design, many of the test points set by such constant distance still has the clearance margin with the neighbor pins. If a test point still has the excess distance from the clearance limit, it is better to move the position of that test point toward the center of the pad to enlarge the distance from the pad edge, since the positioning error is the statistical thing in the practical world and larger margin from the pad edge gives lower probability of the contact failure of probe pin to the pad. As the test step cannot accept even 1 pin contact failure of thousands of (or 10s of thousands of) pins in a fixture by the nature, it gives large difference to the pass rate of fixture pin contact by having more test points with the larger positioning margin than the pre-defined constant distance for all from the edge.

Fig.1-a)	Fig.1-b)	Fig-1.c)
Position the contact point at the center of the pads	Position the contact point at the constant distance from the pad edges	Position the contact point with more margins from the pad edges

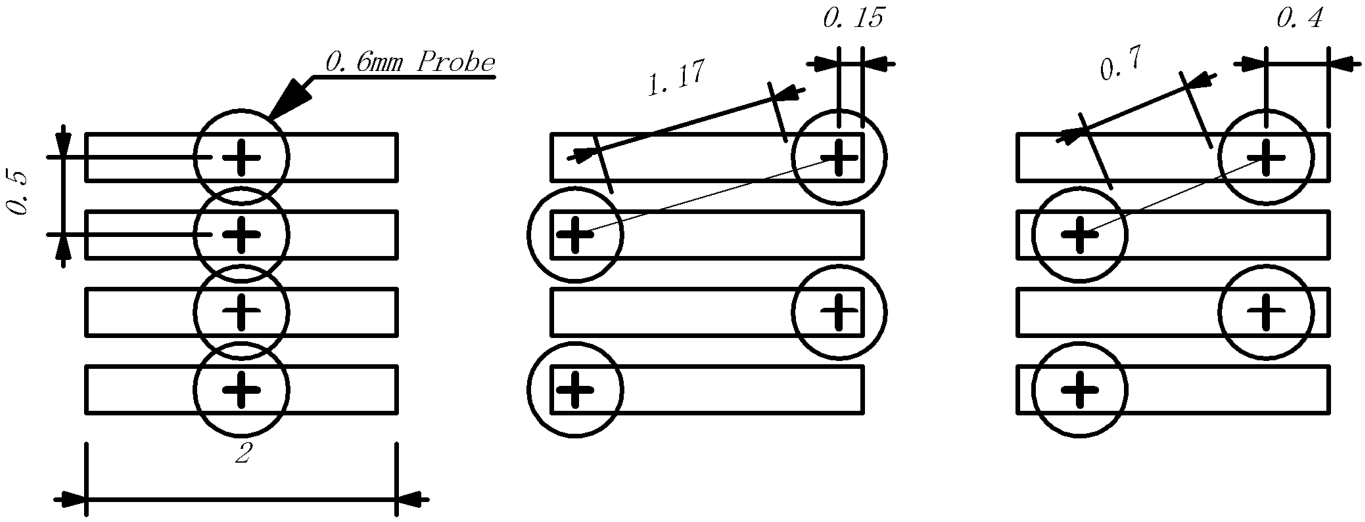

Figure 1

(C) Probe position for the grid tester (universal tester)

For the fixture of the conventional dedicated tester, we can move the probe contact position in the pad as close toward the clearance limit as possible. However, for the grid tester (or universal tester), the positioning logic needs to have the further consideration.

Since the pin positioning by certain grid design is required at the machine side, and no such grid design exists at the PCB test pad side for the fixture, the fixture designer needs to consider the probe pin deflection to connect each points by the fixture. And in general, it is easier to deflect the pin by positioning the pin-pad contact position as far as possible among the pins.

Thus the optimum position of probe pin in the pad is defined by “Large enough distance from pad edge, but largest distance from other pins”. By this optimization, it gives easier pin deflection. And we can produce the fixture which gives the lowest cost with high pass rate of pin contact to pad (e.g. Fig.1-c), thus higher productivity of test process.

OPTIMUM PROBE SELECTION BY THE RESIST DESIGN

As described above, “Position of test contact point and Selection of testing probe type”, the fixture production team try to use as large diameter pin as possible for the fixture type testing to reduce the fixture cost, especially for the dedicated fixture. However, it is not necessary yes to the question if we can use unlimitedly larger diameter pin as long as it does not violate the pin-pin clearance limit. The typical example for the question is the probe selection for an isolated test pad, of which the neighbor pin is located a couple of 10mm far away. It is because, there could be the physical interference, which prevents the normal pin-pad contact, by the PCB design and probe type as described below

These days, PCB design tends to have the smaller test pad and smaller resist open area by the finer pitch design. If we place the large diameter probe for such pad with the small resist open area without thinking the physical interference, there could be the pin-pad contact failure due to the size of resist open area, resist thickness and the probe head shape, as described in Fig.2-a.

Furthermore, there is stronger interference by the size of the resist open area and resist height for the universal fixture, since the probe pin comes with the angle (non 90°) to the contact pad surface due to the deflection, where the probe pin of the conventional dedicated fixture comes vertical (90°) to the pad surface like Figure 2.

As the result, when we select the probe pin, we need to consider the PCB design, fixture type and probe type, such as the diameter size and the head shape, as the parameters for the fixture design. Or there will be a fixture of low pass rate of pin-pad contact, and then the team in the test floor will suffer with the low productivity of the test job.

Fig.2-b) shows the solution to avoid the interference between the probe and resist by selecting the different shape of probe head. Fig.2-c) shows the solution by selecting the smaller diameter probe pin.

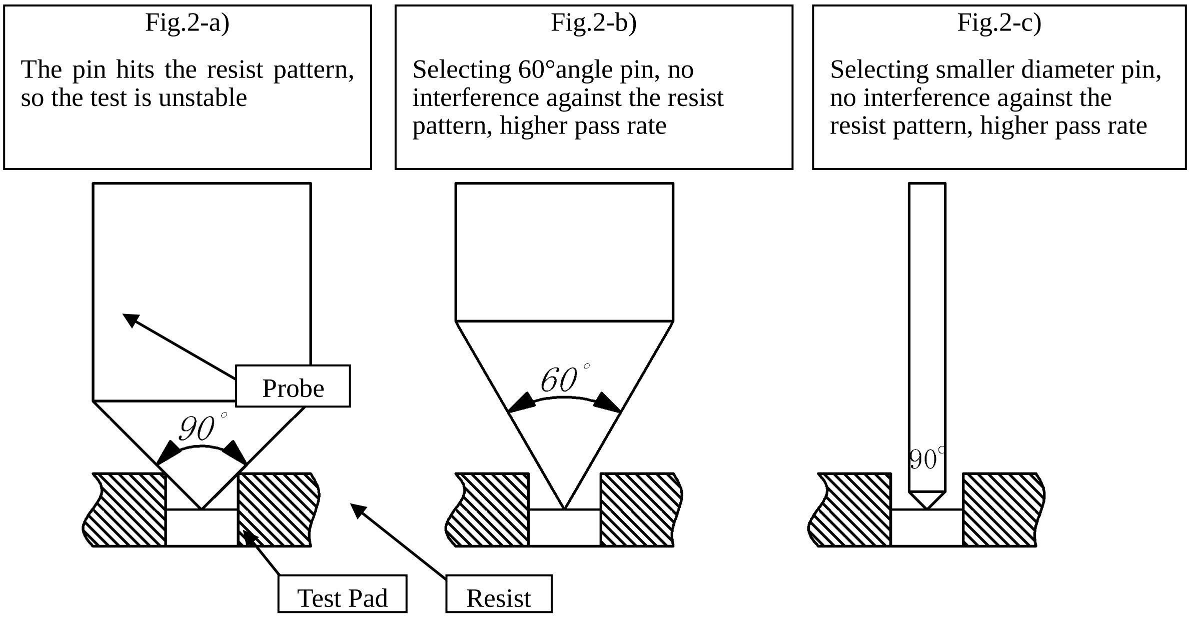

Figure 2

In our company, we are using the in-house custom software to automatically select the optimum probe position and the probe type with the consideration of the physical interference between the probe pin and the resist material.

We, in our company service, are using the multiple custom developed software to respond for the variety of user needs, and providing the test services by the various tester types, and the fixtures production services for the various fixture type testers with the reasonable cost and the short lead time.