Design For Test Guidelines

Introduction:

During which stage of production is test for a printed circuit board (PCB) developed, in the design stage or the manufacturing stage? In most companies, the manufacturing department is responsible for production; therefore, it makes sense that manufacturing takes ownership of this task.

The area where the problems occur in test development often depends on the decisions that were made during the previous stage of board design.

Not all is lost, if some basic guidelines are followed during the electrical design and mechanical layout, R&D engineers can improve the PCB test development process making it faster, easier and do not forget, more cost effective.

The following "design for test" or DFT guidelines can help break down the barrier between design and test, allowing designers to develop better product. The results are since the boards can be tested more effectively; product can be shipped faster with better quality.

Guidelines For A Bed Of Nails "BON" Test Set

Mechanical Guidelines:

- Make test pads or vias, not components or component leads, as the probe targets. This is especially critical for surface mounted boards, because when leads are probed on a SMT board, solder opens can sometimes appear as correct solder joints. With through-hole technology, this rule does not apply, since the leads are less susceptible to solder opens.
- Make the probe targets larger than 0.030 inches in diameter, with the solder as the contact surface. Probe targets smaller then this can be probed, but the tolerances become extremely tight on the boards.
- Place the probe targets at least 0.1inches apart if possible, but never closer than 0.05 inches. This distance determines which type of probe can be used in the board's fixture. The greater the distance between probe targets, larger and more reliable probing styles can be used and the fixture will be less expensive.
- If possible, place all of the probe targets on the bottom of the board assembly. Although top and bottom probing is possible, it is a difficult and costly strategy to implement and requires much tighter tolerances in the construction of fixture assemblies.
- Leave at least 0.06 inches of clearance between the probe targets and components mounted on the board. Components may shift or float during the solder flow process. If there is not enough clearance, the probe target could end up beneath a component.

- Leave a border of at least 0.13 inches around the edge of the PCB assembly where there are no probe targets. This allows for a better vacuum seal and more reliable probing.
- Include at least two diagonally placed tooling holes on the PCB assembly. The tolerance of a probe target relative to a tooling hole should be at most 0.002 inches or better. There should not be any probe targets centered within a radius of 0.285 inches of the tooling hole and no component should be close (0.01 inches) to the tooling pins.
- Make sure there are no probe targets centered within 0.05 inches from the edge of any hole that need to be sealed.
- Consult with electrical designers and test engineers to ensure that probe targets are evenly distributed over the PCB assembly surface. An even distribution minimizes bending and flexing of the PCB assembly, allowing a better vacuum seal and more reliable probing.
- Include at least five probe targets for each power node and as many as possible for ground nodes. The amount of electrical current that any one probe can handle is approximately 0.5 Amperes. Many PCB assemblies require current much greater than this, therefore require more probes, and probe targets to deliver the current. Make sure that power probes are evenly distributed over the board.

Electrical Guidelines

- Associate one probe target with each and every node, or net, on the PCB assembly. This assures that every component on the assembly can be tested for electrical integrity. It also helps minimize changes to the test fixture when engineering change orders are required later.
- Nets that are connected to devices with a low impedance, such as a small value resistor, a Kelvin Measurement should be used. For the Kelvin Measurement, two test points will be needed per net and should be placed close to the component.
- Make sure that all digital components on the PCB assembly can be disabled. All control inputs to the digital components must be linked to a probe target and connected to either a ground or power node through a resistor. This allows the in-circuit tester to disable upstream and downstream digital components so that bi-directional and uni-directional outputs can be tested reliably without interference.
- Make sure that any oscillator circuitry on the PCB assembly is capable of being disabled. This is critical to the success of any digital in-circuit test strategy because the in-circuit tester supplies any clock signal that is needed to test digital components. The tester cannot do this reliably unless the on-board clock is disabled.
- Plan to probe and test all unused digital device pins. This assures that a shorts test can be performed on the unused pins of the digital component and that all of the digital component's pins of the digital component can be checked for minimal functionality.
- Make sure that batteries on the PCB assembly can be completely isolated or removed before or during an in-circuit test. An in-circuit tester works by isolating each node and

then making precise electrical measurements. A battery included in the topology of the PCB assembly can seriously disrupt the measurements.

- Inform the test-engineering department of any self-test features that have been incorporated on the PCB assembly. Features such as built-in self-test, boundary scan for digital components or overall test routines that test large portions of a board, can significantly increase test coverage.

Guidelines For The Flying Probe Test System

Mechanical Guidelines:

- When setting up the U.U.T. board for a flying probe board test, a minimum of three fiducial points should be incorporated into the corners of the U.U.T. board's CAD. Ideally, you want two of the three points in opposing corners of the board and the third point to be set in one open corner to triangulate the board. Acceptable shapes in the CAD are: squares, circles, diamonds, rectangles, double rectangles, annulus, and crosses. Make sure that the fiducial points are not covered with solder. This will guarantee a higher degree of accuracy.
- Make sure that the fiducial points are more than 0.12 inches away from the edges of the board so that the conveyor does not cover them.
- Make test pads, vias, or even component leads, as probe targets. Probing component leads is not the preferred method, but it is acceptable as the last choice for flying probe targets. This is especially critical for surface mounted boards. When leads are probed on a SMT boards, make sure there is 0.01 inches of probe-able area so that the flying probe does not force a solder open to appear as correct solder joint. With through-hole technology, this rule does not apply, since these leads are less susceptible to solder opens.
- If vias need to be probed, make sure that the rest of the cupper annulus is larger than 0.01 inches. Take care that there might be a shift between drilling and the cupper which means the drill may not be exactly in the middle of the via. This tolerance should be added to the target area.
- The U.U.T. has a component size constraint that designers need to be aware of when components are being picked out for this assembly. The maximum height that a component can be on the board's top is 2.20 inches and the component's maximum height on the bottom side of the board is 4.33 inches as tested.
- Make probe targets larger then 0.01 inches in diameter and component leads larger than 0.10 inches, with solder as the contact surface. Probe targets smaller then this can be probed, but the tolerances become extremely tight on the boards.
- If possible, place all probe targets on the bottom or all on the top of the board assembly. Although top and bottom probing is possible, it is more difficult and increases test times.
- Make sure that all nets are accessible from the side where there are no high components. This will avoid the need for testing the board from both sides while reducing the test time by avoiding high components.

- Leave at least 0.03 inches of clearance between probe targets and the components mounted on the board. Components may shift or float during the solder flow process. If there is not enough clearance, the probe target could end up beneath a component.
- Leave a border of at least 0.12 inches around two parallel edges of the PCB assembly where there are no probe targets. This allows the board carrier to hold the U.U.T. without having to build special carriers for the flying probe tester.
- Include at least two diagonally placed tooling holes on the PCB assembly. The tolerance of a probe target relative to a tooling hole should be at most 0.002 inches or better. There should not be any probe targets centered within a radius of 0.285 inches of the tooling hole.
- If fixed pins are used, e.g. on power nets, make sure they are close to the edge of the boards near the conveyor side where the board will be clamped, so that the board is not bent.
- Include at least five probe targets for each power node and as many as possible for ground nodes. Since large amounts of tests require probing on ground, we want to be able to probe multiple targets; this will reduce wear on the board. The amount of electrical current that any one probe can handle is approximately 0.5 Amperes, but many PCB assemblies require current much greater than this, therefore require more probes, and probe targets to deliver the current.

Electrical Guidelines

- Associate one probe target with each and every node, or net, on the PCB assembly. Remember on the flying probe test system, we can target the SMT pads, but it's the last choice for the test engineer to gain access to the net. This assures that every component on the assembly can be tested for electrical integrity.
- Note that the distance between probe targets and components depend on the component height.
- For power and boundary scan nets, test points should be targeted double the size (roughly 40-60 mils) of normal test points and opposite of flying probe locations for fixed pins.
- Make sure that all digital components on the PCB assembly can be disabled. All control inputs to the digital components must be linked to a probe target, and connected to either a ground or power node through a resistor. This allows the in-circuit tester to disable upstream and downstream digital components so that bi-directional and uni-directional outputs can be tested reliably without interference.
- Make sure that any oscillator circuitry on the PCB assembly is capable of being disabled. This is critical to the success when a digital in-circuit test strategy is being implemented on the flying probe test system because the system supplies any clock signal required to test digital components. The tester cannot do this reliably unless the on-board clock is disabled.

- Plan to probe and test all unused digital device pins. This assures that a shorts test can be performed on the unused pins of the digital component and that all of the pins of the digital component can be checked for minimal functionality.

- Make sure that batteries on the PCB assembly can be completely isolated or removed before or during in-circuit test. An in-circuit tester works by isolating each node and then making a precise electrical measurements. A battery included in the topology of the PCB assembly can seriously disrupt the measurements.
- Inform the test-engineering department of any self-test features that have been incorporated on the PCB assembly. Features such as built-in self-test, boundary scan for digital components, or overall test routines that test large portions of a board can significantly increase test coverage.

In the manufacturing industry, some say the cost of fixing board faults increases by 10X at each step of the development and manufacturing process. Engineering can significantly reduce repair cost by improving the efficiency of processes that are downstream. This allows test to find and fix defects at the earliest and the most cost effective stages of the manufacturing process.

Bill Horner, President of The Test Connection Inc, has said, ***"It is the job of test engineering not to change every design for test, rather make design believe in designing for test."***