Connectorless probes simplify digital design

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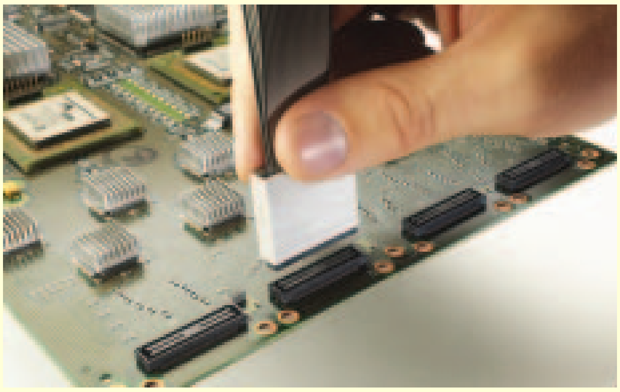
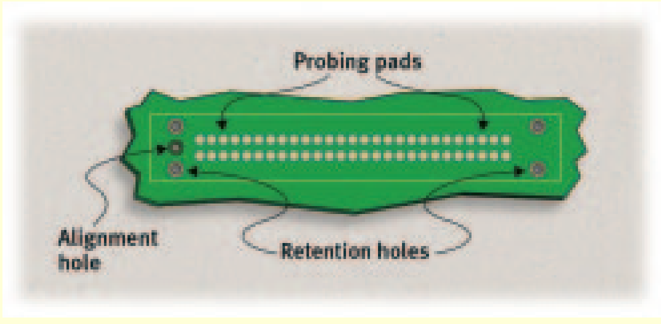
In the past, digital system designers have had to place connectors, like Mictors, on their boards to probe signals using a logic analyzer. Such connectors are both mechanically intrusive to the layout and routing of signals, as well as electrically intrusive to the integrity of the signals.



Designers no longer have to load connectors on their PCBs to perform analysis. Removing the connector from the measurement provides mechanical and electrical advantages.

With the advent of connectorless probes, designers can probe their signals without having to compromise board space or signal integrity. Connectorless probes offer the customer the mechanical benefits of only having to solder four small pins to the board vs. the many fine-pitch connector leads. It also offers the convenience of being able to add probing capability in the field after the boards have been loaded with components.

In some connectorless probes, spring-pin interconnects offer reliable connection to the target over hundreds of cycles in extreme environmental conditions and various surface finishes while offering an extremely low loading capacitance. Small footprints also allow flow-through routing, which give engineers the ability to observe signals in their native routing channels. All these factors make probing more reliable and less intrusive for high-speed applications.



With connectorless probing, the target PCB is turned into one half of the interconnect. This removes the need to machine load fine-pitched connectors.

Mechanical advantages

Connectorless probing offers a number of mechanical advantages over traditional connector-based probing. These advantages include simplification of the supply chain for PCB components, the flexibility to probe on a target board post-manufacturing, and increased mechanical reliability for probing on multiple-PCB plating finishes.

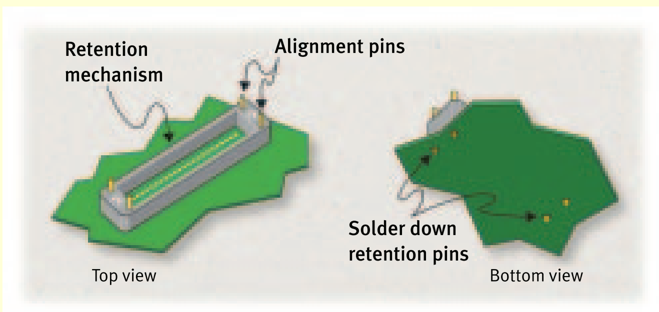
Supply chain simplification–Until now, digital system designers have had two options for probing with a logic analyzer. The first is to include connectors in the design and have them loaded in the SMT process. The second is to attach flying leads to package pins or solder them to exposed pads and traces. Including a connector on the PCB requires a commitment to board real estate and the coordination to ensure that the part is available, purchased and loaded onto the PCB. Using flying leads can sometimes be difficult when accessing large numbers of signals in small geographical regions.

Connectorless probing involves turning the PCB into one half of the probing interconnect. This can essentially eliminate the need to include probing-related components on the bill-of-materials for the PCB. This greatly reduces the supply chain headaches that are typically associated with making the decision to include probing capability early on. With connectorless probing, the PCB designer needs only to place-and-route signals to a non-intrusive footprint comprised of landing pads and small retention holes.

The footprint requires no planning, purchasing or logistical coordination with other parts of the manufacturing organization. Before connectorless technology, the designer would be forced to commit to probing capability before the PCB is loaded with components. Now, the designer has the flexibility to enable it after getting boards back from the load shop. This is done by adding a small plastic retention mechanism with the use of a standard soldering iron found in most labs. Once the retention mechanism is soldered down, the connectorless probe can be attached and used to capture signals. Compare the ease of installation of soldering down the retention mechanism with attempting to solder a hundred or more fine-pitch connector leads by hand.

Probing post-production–The non-intrusive nature of connectorless technology enables engineers to leave the footprint in a production design. This allows designers to include probing capability at any point in the future after the product has been released. This helps reduce the cost associated with probing. For higher volume PCBs, it is not cost-effective to include even one extra connector on every board for probing. With connectorless probing, designers are no longer forced to make a cost trade-off for debug. A product can ship with only the footprint on the board, which costs only the time to route signals to the pads. In the event that debug is needed in the field, simple solder the retention mechanism onto the board and attach the probe.

Mechanical reliability–Not all products requiring debug and validation ever leave the lab. In many situations, the probing paradigm is one of developing



The four pins of the retention module can easily be soldered after the board has been loaded. This is an improvement over attempting to hand load fine-pitch connectors.

large test systems with multiple-probe points that are mated and de-mated hundreds of times. Connector-based probes are limited by a maximum number of mate and de-mate cycles before the connector is no longer capable of making reliable contact. This limit is typically around 50 to 100 cycles. The cycle limit can be reached quickly in a debug environment

The crown-tip of the spring-pin penetrates through contamination, providing a reliable connection across multiple-PCB finishes.

where probe cables are being shared across multiple platforms as a cost-saving measure.

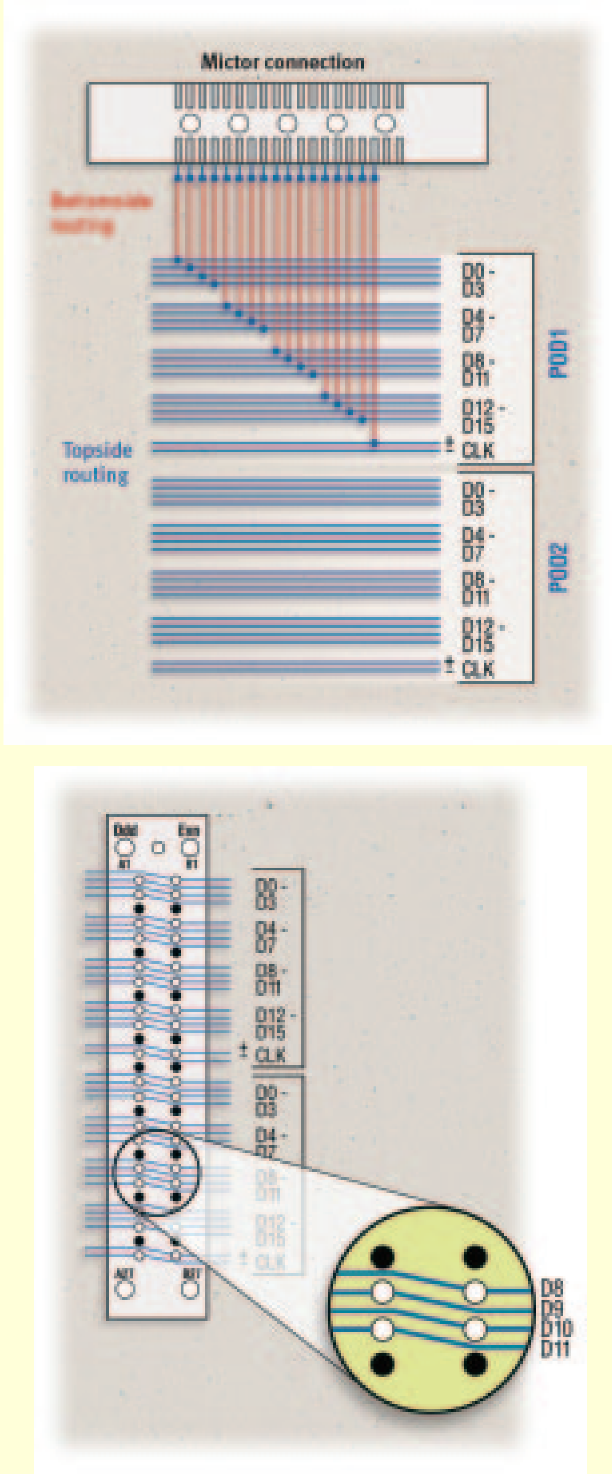
The problem comes when a connector on a test board must be replaced due to damage from over-cycling. This puts the users back into the position where they must hand load a replacement connector. Not only is this a logistical challenge, but this also creates the possibility that pins could be solder-shorted together, introducing false errors into the tests being run. Also, this limited number of cycles will damage the mating connector on the probe, requiring that replacement probes be purchased, thus increasing the overall cost of debug. Connectorless probing solves this cycle limit problem in two ways. First, the interconnect used in a connectorless probe can be typically used for thousands of cycles as opposed to just hundreds. Second, since there is no connector on the board, there is nothing to replace. The compression interconnect on a connectorless probe has up to 0.025 inch of compliance, capable of absorbing the variability of pads coated with hot-air solder leveling (HASL) finish. It also has the ability to pierce through oxides and contaminates on the pad, eliminating the need for cleaning of the surface to be probed.

Electrical advantages

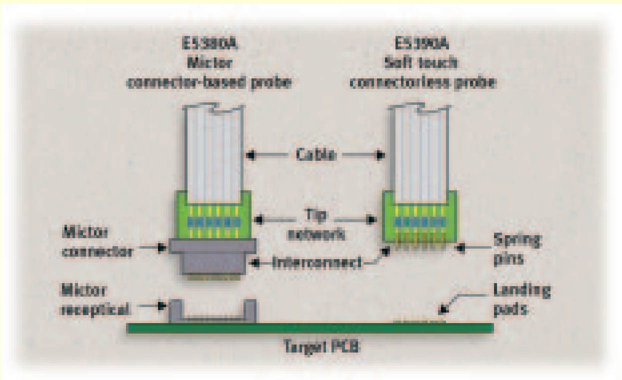
Reduced loading on target when taking a measurement–Loading is a term that refers to how much the original target signal is affected due to the probe. An ideal situation would be that when the probe is connected to a target system, the original signals are in no way altered. This is impractical in the real world. However, if the loading contribution of the probe is small–relative to the speeds at which the target system is running–then the probe can be ignored.

Majority of probe loading comes in the form of parasitic capacitance due to the interconnect structure. Probes contain tip circuitry that forms the transport system into the logic analyzer mainframe. This tip circuitry is implemented using discrete components that contain self-capacitance on the order of ~350fF. The remaining loading capacitance comes from the structure that connects the tip circuitry to the target signals. In the case of a Mictor-based probe, this structure consists of the mating Mictor connectors. In a connectorless probe, this structure comes from the compression interconnect used to contact the landing pads on the target PCB. The difference between these two types of probing technologies is significant. The loading of a Mictor-based probe is 3pF, while the loading of a soft touch connectorless probe is only 0.7pF. Reducing the physical size of the probing interconnect yields greater than a 400 percent loading reduction when compared to Mictor-based probing technology.

Flow-through routing–In connectorless probing, only landing pads are placed on the target PCB. These landing pads are spaced such that signals can be routed between the pads without changing signal layers. This is a new ability over traditional connector-based probes. In Mictor-based probes, the connector that resides on the target PCB prohibits any routing



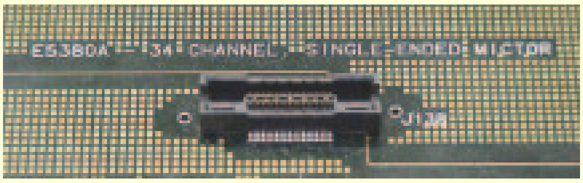
Mictor-based probes block routing channels, which require placement outside of the routing area. Connectorless probes offer flow-through routing, which allows observation of signals in their native environment.



By reducing the physical interconnect size between the probe's tip circuitry and the target signals, more than a 400 percent loading reduction can be achieved when using connectorless probing vs. Mictor-based probing.

through the connector due to its use of SMT and through-hole technology. This means that when observing signals in a routing channel, the Mictor connector needs to be placed to the side of the traces, and stub-traces are used to make the connection to the connector. Placing the connector off to the side has the disadvantage of increased loading due to the need for stub-traces. Also, more PCB area is required to accommodate the connector placement. With connectorless probing, the footprint can be placed directly in the signal path with minimal disturbance to the routing of the signals.

Disconnected–A final electrical advantage of connectorless probing is the reduced loading of the footprint when the probe is not connected. When a Mictor-based probe is disconnected, a mating connector still resides on the target PCB. In most cases, unused stub-traces are also left floating. The parasitics of the unused probe points are large enough so that they cannot be ignored.



The connectorless footprint leaves only a small SMT pad that has negligible loading. This means the connectorless footprints can be left in designs allowing field-failure debug.

Most designers take the connector and stub-traces out of the design before going to production. Connectorless probes do not have this problem. Since only the landing pads are left on the board when the probe is disconnected, there is little to no loading due to the pads (~80fF). Also, since the connectorless footprint allows flow-through routing, there are no stub-traces present to have additional loading. The advantage is that the connectorless footprint can be left in a production design without degrading the performance of the system. Designers can now analyze field failures using the same testbenches that they used during prototyping because the design still possesses logic analyzer probing points.

As DDRs continue to increase, the standard techniques for performing logic analysis probing are now becoming obsolete. Traditional Mictor-based probing is being replaced with connectorless-probing technology, which possesses a suite of mechanical and electrical advantages over Mictor-based probes. Designers migrating to connectorless probing are reaping the benefits of a more reliable connection with minimal loading and simple-to-implement features on the target PCB. The technology allows designers to achieve successful logic analysis as they push their systems to higher data rates. □