iNEMI
Technology Roadmap

2019 Board Assembly—Press-fit Section

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Press Fit Introduction

This section will explore the evolution of Compliant Press-Fit Pins, Connector trends, key design aspects, placement, insertion, tests and inspections, associated issues and prioritized research along with development needs.

The Press-Fit Compliant Pin is a proven interconnect technology to reliably provide electrical and mechanical connections from a Printed Circuit Board to an Electrical Connector. Electrical Connectors are then interconnected together providing board to board electrical and mechanical connections. Press-Fit Compliant Pins are used on Backplanes, Mid-planes and Daughter Card Connectors. OEM (Original Equipment Manufacturer) designs continue to use press-fit connections to avoid challenges associated with soldering, rework, thermal cycles, installation and repair. Figure 1 illustrates compliant pin, insertion to plated through holes, integration of pins to housing, PF connectors installed on PCB and examples of High-Speed Connectors.

A Press-Fit Compliant Pin is typically formed via a flat sheet of copper metal stamping and coining process using precision punch and die tooling set. The Compliant Pin section is designed to dynamically compress during press insertion into the PCB to adapt to a given finished hole diameter range as specified by the connector manufacturer. The Compliant Pin interference will create a gas tight mechanical interconnection to the PCB PTH thus providing a proven, dependable and reliable interface.

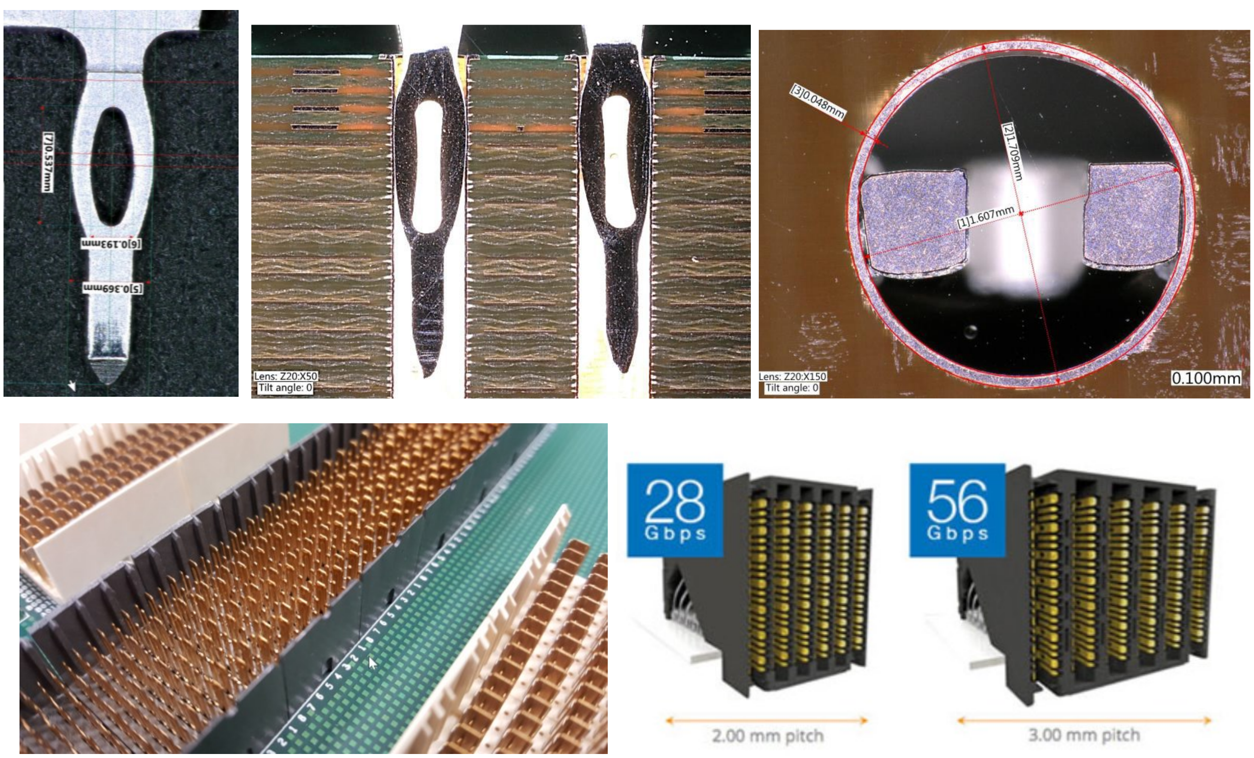

Figure 1. EON (Eye of Needle) Style Compliant Pin and Cross-Sectional View within PCB. Press fit Connectors Installed on PCB (Courtesy of Flex) and ExaMAX High Speed backplane connectors

Finished Holes Sizes

Press Fit Compliant Pins require a highly controlled drill and FHS (Finished Hole Size). A narrow FHS (Finished Hole Size) tolerance of +/- 0.002" (.05mm) is typically agreeable to PCB Manufacturers. Trends for smaller FHS tolerance are being seen, but not yet achievable to 0.038mm. The PCB drilled and finished holes' sizes are specified by the connector manufacturer and must be strictly followed. PCB PTH drill and FHS variances to accommodate a different surface finish types must be studied, validated and reported by the connector manufacturer. Failure to comply with connector manufacturer drill and FHS recommendations will impact compliant pin insertion and retention forces.

Smaller Compliant Pins

The general trend in compliant pin press fit designs has been toward smaller diameter vias and shorter pins to improve the electrical performance of the signal launch. As the market continued to require increased and improved signal integrity, system architects are faced with a choice between the signal integrity benefits of SMT and the manufacturing benefits of press fit. By improving the compliant pin launch performance, the recent generation of connector systems has enabled the market to achieve the necessary electrical performance while maintaining the process benefits.

Back drilling has become very popular to aid in signal performance, reduced crosstalk or interference and noise. Controlling the drill process to ensure drill depth, press pin insertion depth and verification has been a challenge.

Press Fit Pin Process

Placement & Insertion

The industry has relied on human manual placement methods to load connectors onto the PCB before the press operation. An optimized process employs using a poke-yoke method where the operator is guided either by a light station and or simply uses a visual diagram or drawing to locate and place the connector correctly. This has produced relatively low yields and has driven difficult repair processes

Manual hand insertion has become increasingly more difficult as Compliant Pins are getting smaller, shorter and having higher density. Cycle time for manual placement has increased by an estimated 20% and requires experienced operators with an ability to sense correct placement.

The use of automated machines to perform Compliant Pin stitching, comb block loading press, pin tip true positioning / straightening. Connector pick, place and press steps have all been unique highly customized machines. Equipment Manufacturers return on investment to create these types of machines has been slowly adapted so few sources and options have existed until 2018.

Currently there are a limited number of equipment vendors and or high-cost robots to automate the connector placement onto the boards. One reason for the lack of equipment is the lack of connector package standardization of connector trays. Connector manufacturers tend to use trays that match their connector design and packaging. A collaborative effort has not yet been made in the industry to standardize connector trays. This standardization will go a long way towards having machines that can automatically place parts for the press operation. This packaging/feeding standardization effort will most likely need to be driven by the large OEMs and EMS (Electronic Manufacturing Service) partners. In the interim 3D Printers are being used to create customized trays to enhance the ability to automatically pick, inspect, place, press and inspect press-fit connectors. See figure 2 as an example of 3D printed tray.

Figure 2. 3D Printed Trays for Consistent Component Presentation. Trays can be loaded by hand or by robotic solution (Courtesy of Flex)

As cost pressures increase and compliant pin size density decrease, throughput will become more of a focus, and there will be more demand for automatic placement machines provided they can do some (if not all) of the following steps: pick connector from package, pre-optical or laser inspection of the pin tails for true position verification, placement onto the PCB, inspection before the press fit operation. Automatic inspection and defective connector handling controls needed for diagnosis.

The actual connector pin tail's size, alignment, true position and average offset of the wafers play a role in the ability to properly place a connector. Use of automated optical inspection (AOI) process, automated 3D profiling for pin tail alignment and true positioning would provide some assurance that the connector pins are placed into the holes without stubbing against the PTH wall.

The insertion and press step are the most critical portion of the press-fit process. Use of proper feeding methods, pre-insertion pin inspection, pre-seating, press equipment, insertion tooling, support fixtures, compliant pins and PCB's that comply to the drill and finished hole size conditions ensure a sound process with reliable results.

The need for a market standard system for the automatic pick and placement of connectors has been requested and understood. Equipment Manufacturers report that different platforms to address this need in the assembly of PCBs were released to the market, but due to market conditions, sales were very weak. One solution was specifically tailored to the pick and place (not press) of connectors in order to work with equipment in the manufacture of large backplanes. This system loads connectors onto the PCB and feeds the PCB into a press system for the press fit operation. The second solution was a complete pick, place and press system. This inline system represented single or paired machine solutions for the application of compliant pin connectors. The second solution was limited in board size (18 x 30) and force (3 tons), which focused it more on small backplane \ mid-plane and daughter card applications. Note that both systems offered inspection of the connector pin tips after it was picked from vacuum formed tray, tube or vibratory feeder to assure that pins were present, in the proper arrangement, and that they were not bent outside of a defined tolerance. Both systems have been withdrawn from the market due to low demand.

Most OEMs have traditionally distributed their HD Backplane and Line card production to multiple EMS partners and in multiple geographic locations, resulting in a difficult ROI justification due to relatively low volumes across many manufacturing lines. The top 5 OEMs have historically outsourced to >10 EMS partners at >20 sites worldwide. The forecasted growth of 5G/10G (and beyond) infrastructure, with potential market domination by the larger OEMs, may lead to more consolidated investments to keep pace with the volume ramp demands, quality initiatives and manufacturing cost reduction targets. This growth should fuel a resurgence in the automation market for HD interconnect (Press-Fit) solutions. New Backplane designs have also driven panel sizes of greater than 20"x40" and up to 40kg in mass.

Current systems on the market range from semi-automatic presses through fully automatic press systems. However, the automation has only pertained to the actual press cycle. Loading of the connectors onto the PCB has still been manual by human hands, up until recently. New "Paired" solutions for pre-seating + final press has been developed and available now.

A re-evaluation of the need for a pick and place solution has been expected with the recovery of the telecommunications and networking industry. Also, the move to smaller pins and denser pin fields is expected to further drive the need for a pick and place option. As the market evolves, one potential solution is modifying an existing automatic press system to act as pick and place and\or a pick, place and press solution. Another potential solution is to take an existing odd form pick and place system and modify it for use with connectors.

The decision point between automated versus manual press fit methods is challenging and needs to account for connector density, yields and cost justification.

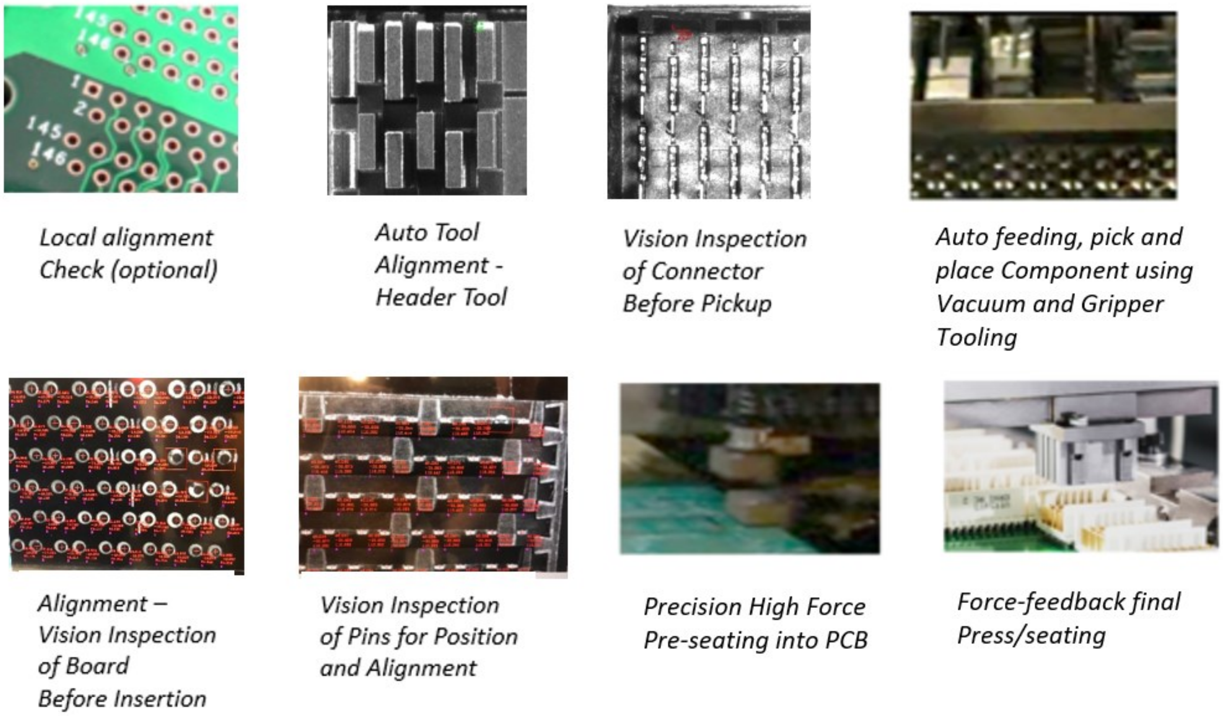

Figure 3. Pre-seat + Final Press Process Steps

(Courtesy of Flex and Syneo)

Pre-Inspection

Pre-Inspection is crucial for the newly proposed pre-seating process. Accurate and reliable pin location tolerance inspection and component alignment provides a validation before these connectors are inserted, driving higher yields and a simplified final press process (part is already aligned, and eyelet pins are partial inserted). The size and shape of pins, density of pin arrays, and connector geometries pose a wide variety of challenges for these solutions.

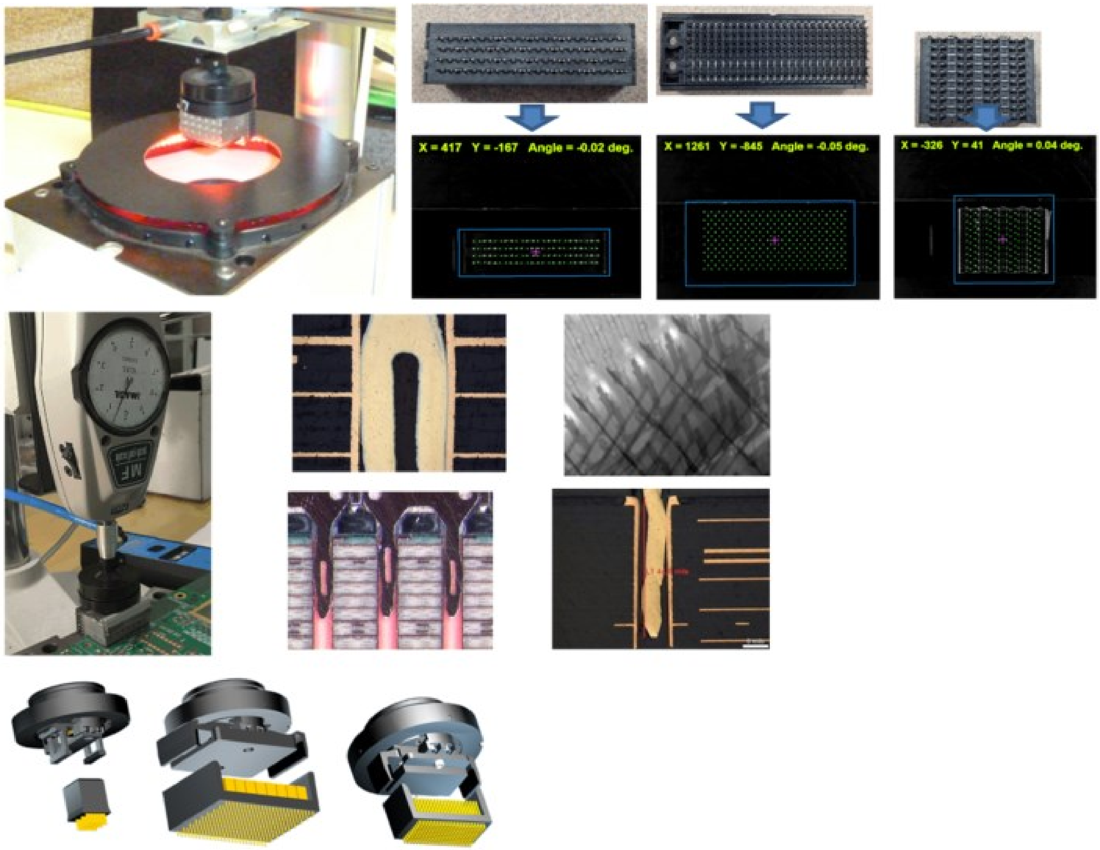

Figure 4. Pre-seating -Vision inspection for pin deformation. Example images of HD connector inspections.
(Courtesy of Universal Instruments)

Pre-Seating

The pre-seating process development will require some level of validation and maturity to determine optimized pin-to-hole tolerance allowances as well as proper component handling and pressure/force parameters to ensure the required yield rates during the final press process.

Connector feeding to the placement cell

The first step in pick and place is proper presentation of the connectors to the pick and place mechanism. Although automatic component placement (odd form components) has been around for many years, connectors pose a unique challenge for a variety of reasons.

1. They come in many sizes and shapes which can make pick and place tooling extensive and expensive.
2. The pins are rather fragile, so care must be taken to prevent damage at every step of the process.
3. Many connectors are shipped from the manufacturer in thin wall disposable plastic trays. These trays are imprecise and weak to the point that in many cases they are not usable in an automated pick scenario. Until packaging is improved it is likely that in some cases connectors will need to be transferred from the shipping packaging to something more amenable to pick and place. This adds labor and increases the likelihood of pin damage.

4. In addition, trays must be fairly large to accommodate a reasonable number of connectors. This challenges the pick and place system by requiring a large travel area in order to reach all of the trays and/or requires elevator un-stackers which can be expensive.

Connector pin tail inspection

The only viable means of inspecting connector pin tails is by using a machine vision system. This system must be capable of accurately detecting the presence and position of each pin regardless of pin length, connector length, pin tip profile, material, finish, and background reflections from the connector body. The large size of some the connectors requires a large area vision field. Lighting is always the first and most critical step in successful image acquisition. Multiple lighting schemes may be necessary to cover all the variations. Once the pin tips image is acquired the calculations required to determine pass/fail status is relatively straightforward. Fortunately, this same data can be used to guide the placement head to the proper location on the PCB.

Connector placement

The true position of the pin tails has a natural variation from the manufacturing process that makes the placement accuracy more stringent than it might appear. The trend toward smaller pins and holes makes placement exponentially more difficult as the pin is more fragile, and the placement target becomes smaller. The placement system must determine the best placement position that takes all pin positions into account to find the best possible alignment between the pins and holes. This becomes an exercise of minimizing the maximum +/- pin tip deviations in X & Y directions rather than singly finding the centroid of the pin array.

Connector pressing

Connector pressing using servo electric presses has been the gold standard in the industry for over 20 years. The benefits include precise control of the speed, position, and force which cannot be achieved using pneumatic or hydraulic means. In addition to servo control, the support structure must be very rigid to prevent slamming connectors to the PCB surface as the required force suddenly drops when the compliant section collapses as the pin enters the hole.

To date, nearly all connectors are hand placed throughout the board, followed by manual or automated pressing. When using automated pressing careful design of force feedback can detect a connector that is dispositioned on the PCB whether it was placed incorrectly of was jostled out of place at some time after placement. Transferring the loaded PCB into the automatic press can be a source of this problem. If the PCB is successfully loaded into the automated press, there is a significant possibility of connectors moving due to other sources of inadvertent PCB movement. One such source of movement is the press tooling itself. As the tool is retracted from the just pressed connector it can momentarily stick in the connector which causes the PCB to raise slightly. When the tool breaks free the PCB snaps back down with significant vibration. The causes of connector movement after placement can be minimized but never eliminated completely. This problem can be eliminated by picking, placing, and pressing each connector in sequence so there are never loose connectors on the board.

Post-Inspection

Inspection is one of the most critical areas of the press operation. Regardless of the type of pin deformation as illustrated in figure 5 (crushed, bent-under, broken-off, smashed, etc.), the primary concern is a connection that may pass an open/short electrical test but fail subsequently in the field due to either loss of signal integrity or the connection opening up. This can occur if the pin shorts to the top of the barrel and passes the electrical test.

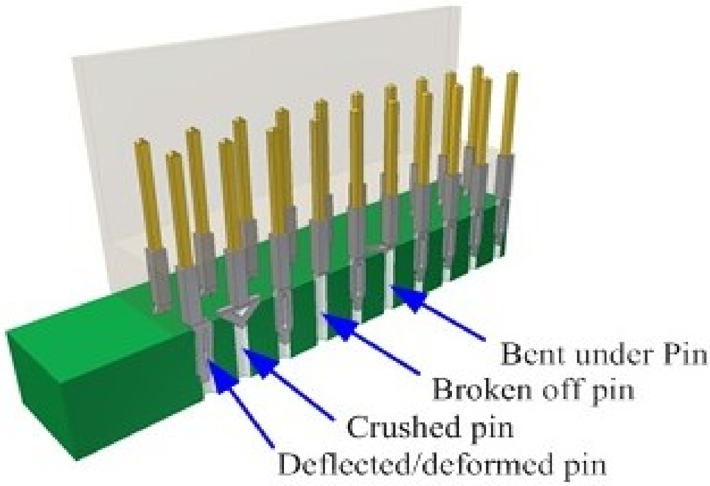

Figure 5. Typical Press-fit Compliant Pin Faults

(Courtesy of Robat)

If the pins are long enough to protrude through the board, inspection can catch a pin that has not protruded through the board by AOI (Automated Optical Inspection) or visual inspection. However, if the pin is short and the PCB is thick, the pin is not visible thus limiting defect detection. AOI Equipment can easily inspect and measure Pin Tip True Position but cannot easily detect presence of a pin tail buried in a thick PCB PTH. Alignment of Pin Tip True Position measurement location (data or reference point) and equipment method is encouraged between the Connector Manufacturer, Customer and Contract Manufacturer. An example of Pin Position Measurements by AOI is presented in Figure 6.

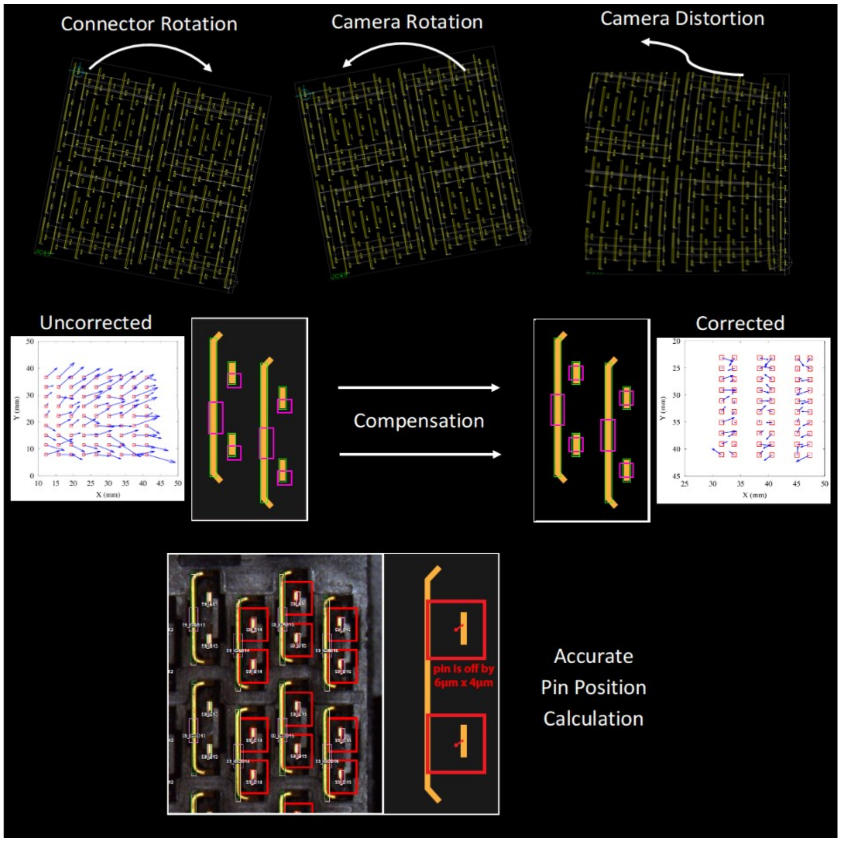

Figure 6. Pin Position Measurements by AOI

(Courtesy of Robat)

For accurate pin position measurement, the AOI system must compensate for connector rotation, camera rotation and camera distortion. This enhances the pin position measurement accuracy relative to the inherent resolution of the optical system.

Automatic Connector / Pin Placement and Pin Tail inspection

The need remains for automatic machines to provide connector pick, pin inspect, place and press process steps. Accurate pin placement and tail inspection of the connectors is needed. As the industry becomes even more cost competitive, connector pins and PCB PTH's get smaller, this need will become more pronounced to improve throughput and yields. One of the important steps in automating the process is to standardize the connector trays for the machine between companies.

Challenges and Issues

The development of smaller compliant pins, while providing necessary electrical improvements and enabling increased density, also poses a number of design and manufacturing challenges:

- Smaller PCB vias required – board thickness / aspect ratio limitations
  - Smaller holes in thicker backplanes drive higher plating Aspect ratios
  - Smaller PCB holes and Pins with less positional tolerance make part placement more difficult.
- Alignment of Connector Manufacturer to OEM Equipment Manufacturer to specify recommended PCB Drill and Finished Hole Size requirements.

  - PCB Fab drawings must reflect the Connector Manufacturer PTH Drill and Finished Hole Size requirements.
  - Allowance of PCB venders to adjust drill sizes that differ from the Connector specified requirements may create Pin insertion and retention variances.
- PCB Fab Process of Controlling PTH requirements (tolerances, drill diameter, plating thickness and true position)
- Counter boring or back drilling holes with consistent results has improved
- Board Assembly capabilities (press machine: manual or computed)
- Pins have reduced PTH compliance, less energy available, lower insertion and retention forces. Lower Pin Insertion Forces. Limited Bent Pin detection.
- Compliant Pin Column strength - pin buckling. Pins are much easier to bend or damage
- Bent Pin detection more difficult
  - Inspection capability of Pin Tail presence via X-Ray or AOI
- Pin Tip Location - Board Assembly capabilities; alignment of measurement plans
- Commitment and investment in new equipment technology
- Uniform set of requirements of PTH size and tolerance for industry
- Press Fit Compliant Pin Cracks:
  - Technical Work Group members have reported isolated cases of small cracks observed on compliant pin sections after insertion into plated through holes. These cases are reported when having the smallest hole size within the lower tolerance limits. These cracks range from surficial to those migrating from inside the eye of the needle to side of pin. This condition seems more common on Nickel Gold plated (ENIG) holes with Press Fit Pins. Although the issue has been brought up by a few members from different companies, the occurrence and frequency data are limited based on non-disclosure at this time. There have been no reported field failures or performance issues compromising operation. Therefore, in some use conditions the Press Fit Pin cracks have been deemed acceptable.
- Figures 7 and 8 below illustrate cracks and bent pins detected by cross-section and Computed Tomography (CT)

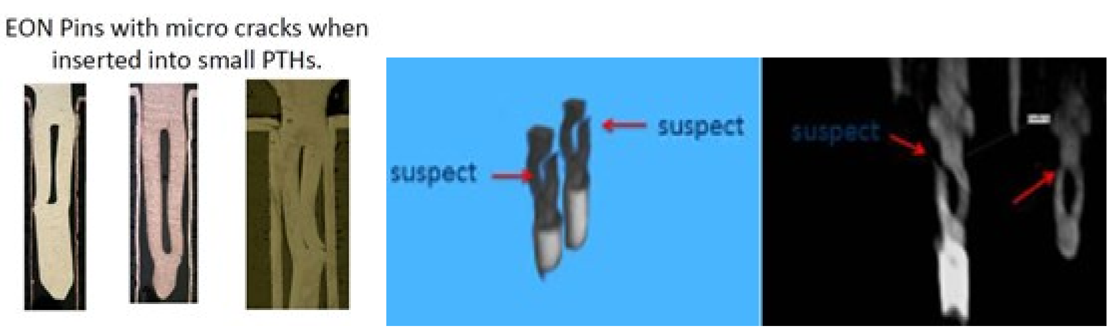

Figure 7. Optical Cross Section of deformed inserted EON Pins. 3D X-ray Image and CT slicing of Cracks on Inserted EON Pins

(Courtesy of Flex)

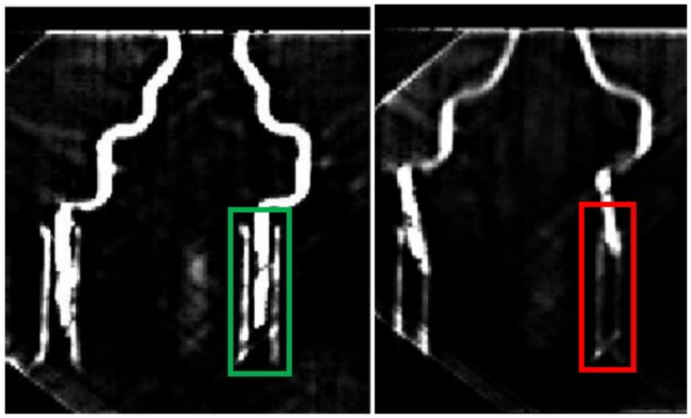

Figure 8. CT slicing of inserted pins. Left, good press fit with fully inserted pin no bend. Right, bad press fit with not fully inserted pin that starts to bend

(Courtesy of Flex)

Inspection Solutions

- Improved inspection Equipment capabilities required:
  - Repeatability and Reproducibility of data with low false defect call rates
  - AOI or Laser: equipment manufacturers have created automated optical inspection machines with ability:
    - To look into a PTH from the bottom side to validate pin presence and insertion depths.
    - Check pin tip true position and alignment
  - X-Ray inspection: equipment manufacturers have created automated X-ray inspection equipment to easily measure pin insertion depths and detect bent pins under Connector housing.
  - Large PCB Equipment with PCB size >508mm (20") x 609mm (24")
  - Create inspection algorithms to automatically detect bent pins
  - Pin depth measurement using 3D imaging
  - Automated Pin Profiling Inspection using 3D imaging
- Plastic technology using a transparent housing to aid inspection of pin presence seems to be a viable option using Polycarbonates, Polyether sulfones or Polyetherimides. While these plastics may provide visibility to pin insertion effectiveness, mold ability and heat exposure limits may need enhancement.

AOI Mating Side Bent Pin Detection

Whilst the existing 2D method can satisfactorily detect whether pins are straight to very small tolerances, there can be some false failures due to the following combination of factors:

a) The shape of the pin tips per connector type are sometimes not consistent. This is usually due to inconsistent quality and/or pins that have been cropped and not machined.

b) Pin tips that do not have a well-defined bright spot on the tip, making it difficult for the camera to detect the center

c) Pins where the base is brighter than the tip (pin shoulders are mistaken for the pin tip).
d) Offset chamfers on pin tips also make it difficult to detect the true center of the pin.

A new 3D AOI method that is currently in development takes images of every pin region at different angles. Advanced software combines and processes each set of angled images and is able to calculate the true center-line position of each pin.

Figure 9 gives images of some examples of the variable angles taken. The goal for this new technique, is to overcome the issues mentioned in a – d above and therefore achieve very low false call rates as well as further increased positional detection accuracy. The images show very clearly defined pin tips, including the offset angled tips.

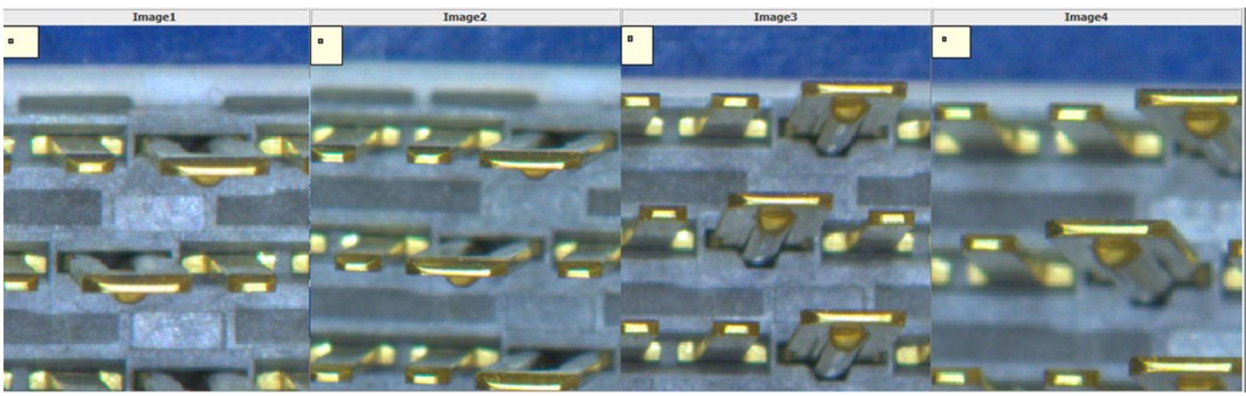

Figure 9. Images of inserted pins at different angles

(Courtesy of Robat)

X-Ray Inspection

2D X-Ray and 3 D-X-Ray (Computed Tomography)

The most difficult and elusive inspection of all in the press-fit connector process remains when two connectors are pressed from both sides of a board with pins from each connector going into the same hole. New robotic X-Ray inspection techniques now exist as a routine production test that is scalable to test the largest backplanes and will detect these press-fit defects even in situations like this where two compliant pins share the same plated through hole. 2D X-Ray and 3D X-Ray, also called Computed Tomography (CT), techniques have pros and cons for the inspection of PF connectors, see Table 1. CT technique gives access to slices (virtual cross-sections) and 3D representations of areas inspected. Figure 10 below is showing a 2D X-Ray image and an X-Ray slice (Computed Tomography) of the same area to detect bent, missing pins. While inspection methods to detect Bent Pins under the connector base remain a challenge, automating X-Ray algorithms to validate a pin presence within a PTH (plated through hole) have proven successful.

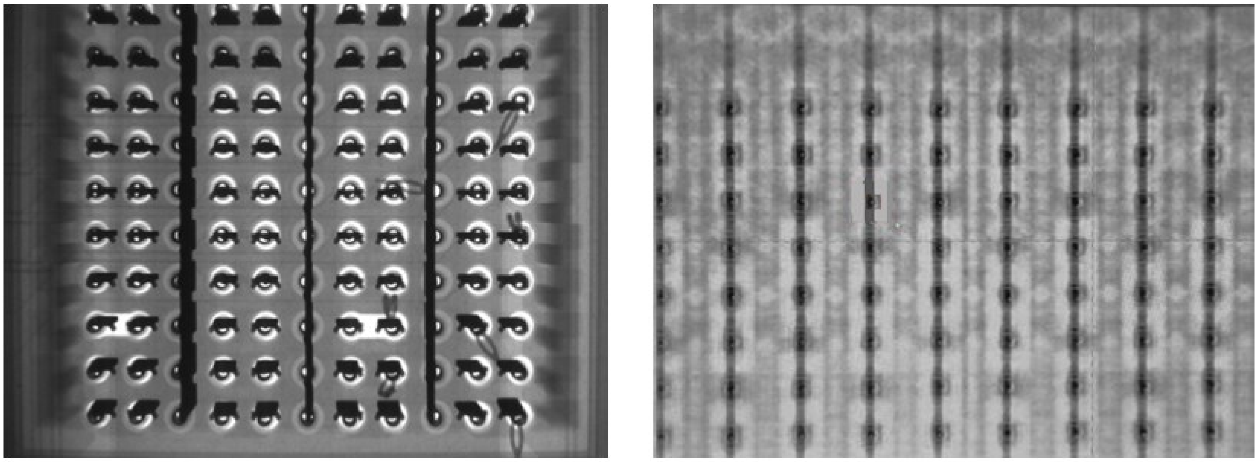

Figure 10. 2D X-ray image of Bent-under and Crushed EON Pins on a Backplane and X-Ray slice (CT) image

(Courtesy of Robat)

Technique	Pros	Cons
Slicing (CT)	1. Can Potentially find Crushed and Missing Pins as well as Bent Under Pins	1. False calls possible due to bow in the board 2. Cannot detect metal debris under connector 3. Images are difficult to interpret and review
2D Imaging	1. Easy to interpret images and review faults 2. Can detect metal debris under a connector	1. Missing/Crushed Pins more difficult to detect

Table 1. Slicing technique (Computed Tomography) and the 2D imaging technique with their pros and cons

(Courtesy of Robat)

X-RAY DEVELOPMENT

There are two new techniques under development that will use angled images to detect compliant pin faults. These techniques are described in Figures 11 and 12 below.

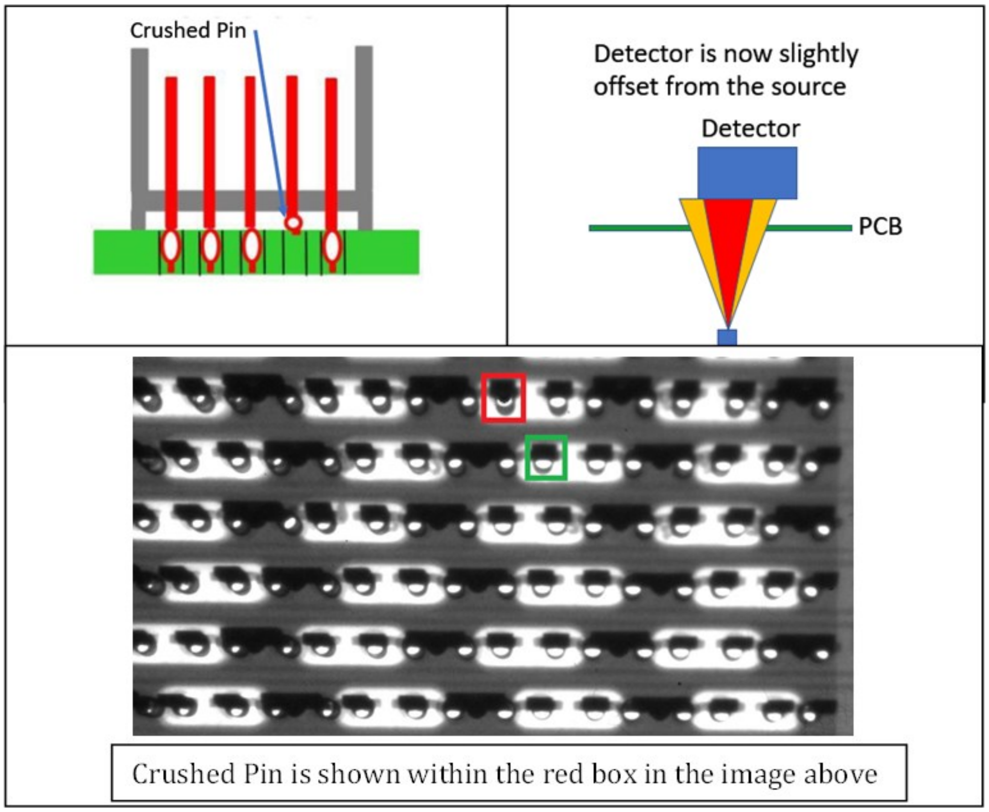

Figure 11. *Technique 1 This will use small, angled images by offsetting the source and detector.* (Courtesy of Robat)

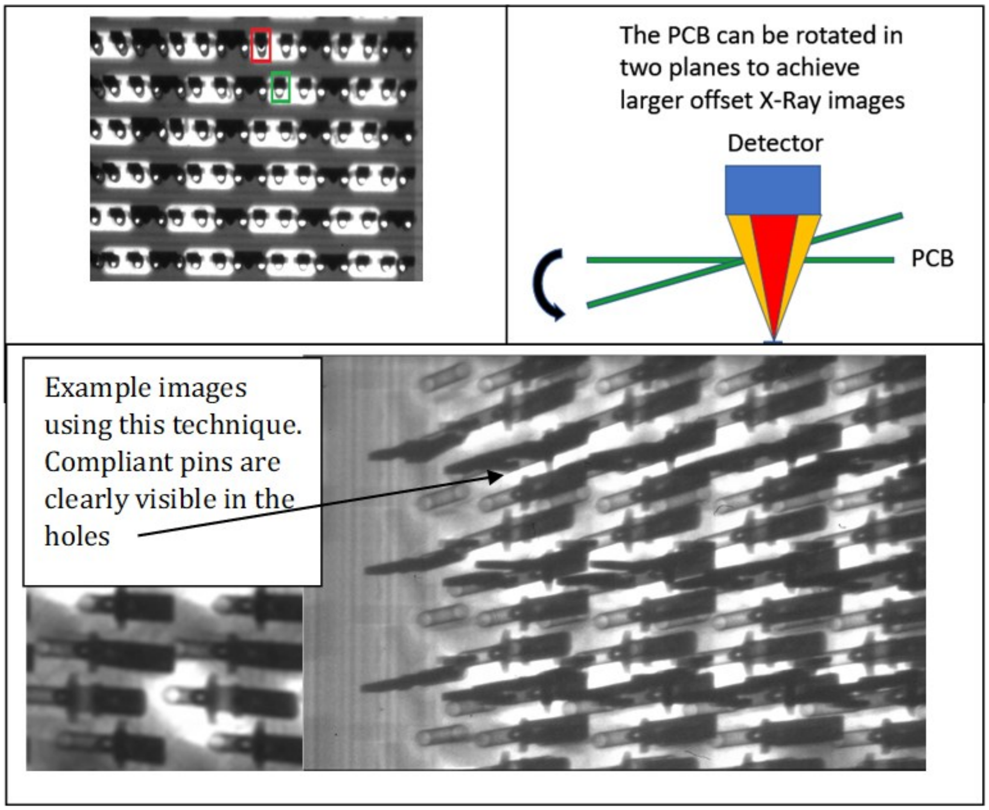

Figure 12. Technique 2 will use larger angled images by angling the PCB under program control.

This method will enhance the machine's ability to find missing and crushed pins. It will have the added advantage of maintaining the maximum power of the x-ray beam being concentrated in the target area for best contrast and shorted exposure time. (Courtesy of Robat)

New Alternative method for detecting Compliant Pin Faults – 'Pin Depth Measurement'

This technique was initially developed for detecting bent under pin faults on the right-angled connectors fitted to Line Cards. These connectors use the same press fit compliant pins to those found on backplane connectors and therefore the same faults can occur during the process of pressing the connector into the PCB.

Both AOI and X-Ray are used to detect compliant pin faults online Cards, however both techniques have their limitations.

AOI can be used if the PCB is not too thick. However, pin tips can start to get difficult to detect when the PCB thickness is greater than 3mm, particularly when the compliant pins are in the range of 1.0 – 1.3mm long. Whilst the AOI method can detect the presence of the pin tip in thinner boards, it still cannot determine how far the pin has entered the hole and therefore cannot check the connector has been fully inserted.

The right-angled edge connectors typically have substantial amounts of metal content. This can be in the form of a right-angled bracket that holds the individual wafers together and/or metal content within the body of the connector that carry the ground/signal contacts. If the connector has only a small amount of metal content, X-Ray can be used successfully. Again, as with AOI, X-Ray cannot always determine whether the connector has been pressed correctly.

The new Pin Depth measurement method, illustrated in figure 13, is not affected by board thickness, length of the compliant pin or metal in or surrounding the connector. It uses a lightly sprung pin that enters the hole and touches the top of the compliant pin. It uses a combination of micro-encoders and very accurate opto-switches to detect where the tip of the pin is relative to the board surface. This test method also can compensate for board thickness variation. The result of all this technology is a measurement resolution of ±0.1mm.

This method can be used equally well on single-sided backplanes and double-sided backplanes (with offset connectors).

This test method has been proven effective with boards up to 10mm thick and on press fit mounting hole diameters as small as 0.26mm. This is equal to the lower limit of a Ø0.31mm finished plated through hole with a tolerance of ±0.05mm.

Test speed (Max.) = 24 Holes a second.

BACKPLANES LINE CARDS

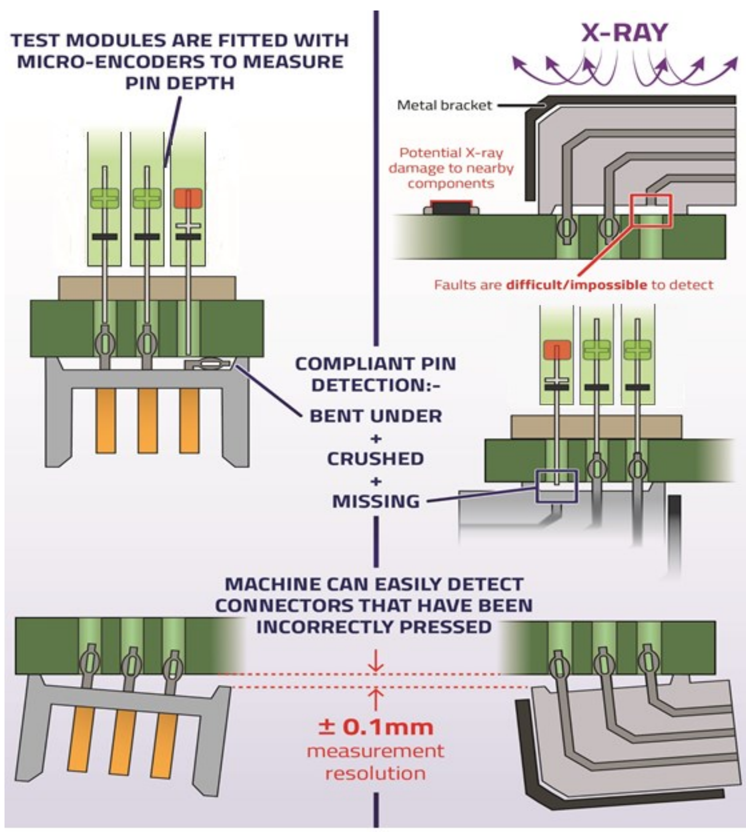

Figure 13. Pin Depth measurement method

(Courtesy of Robat)

3D Automated Press Fit Pin Profiling Inspection

A new system has recently been introduced which provides a metrology-based inspection of press fit pins on Backplane / PCBA assemblies up to 127cm x 76cm, (50" x 30”). The system uses a non-contact confocal line sensor to scan across the backplane, creating a 3d profile of the connector, pins and holes. Measurement density is typically 200,000 points per cm^2 up to 500,000 points per cm^2, depending on desired resolution / production throughput. This method enables detection of Bent Pins, Missing Pins and Pins Crushed under a Connector Housing. Figures 13 and 14 are illustrations of this method.

The Confocal technology has been available for quite some time but was previously unusable for pin inspection due to taking hours to profile a single backplane. However, recent product developments have increased the density of the confocal line sensor to such that the technology is now capable of meeting production throughput requirements. Today, the typical time to profile and inspect a high density 2cm x 25cm connector is approximately 18 seconds.

This technology is now more commercially viable.

The advantage of using a metrology-based system is that the pass/fail criteria is based on quantitative values, creating a more robust test/inspection platform than qualitative image-based systems. In actuality, test program creation & pass/fail decisions are closer in nature to In-Circuit test rather than AOI/X-Ray. This new Press Pin Inspection method providing ability to find Bent and Missing Press Fit Pins and is now available for inspecting PCBA and Backplanes.

To keep up with the continuing reduction in pin diameter, the supplier has a next generation 3D profilometer in development. Current capability for pin depth measurement on an 8mm thick PCB, is a pin approximately .5mm in diameter. The new target is to provide capability of depth measurements on pins .2mm in diameter, (in an 8mm thick PCB). This capability should be available by late 2018.

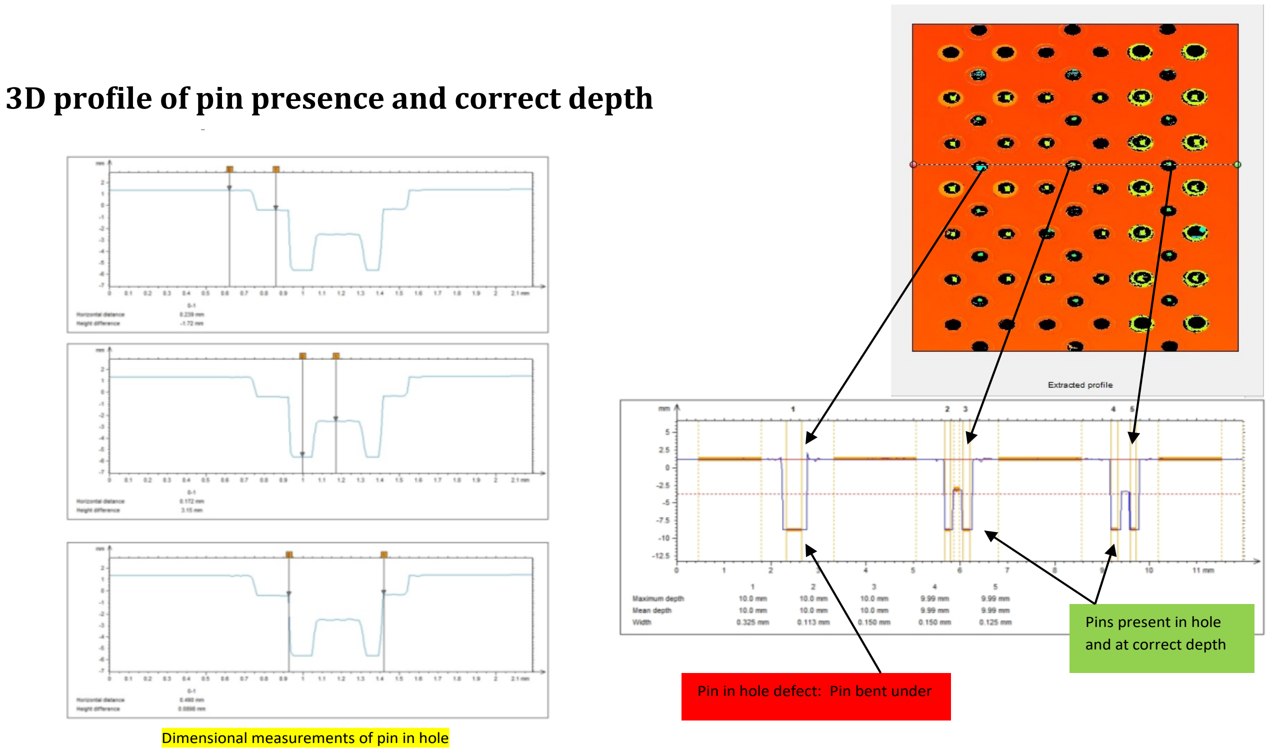

Figure 14. 3D Profilometer inspection of a pin presence and depth in holes

(Courtesy of Toptest)

RAW 3D MEASUREMENT DATA OF ONE PIN IN HOLE MEASUREMENT
VALUES ARE IN MICRONS, POINT CLOUD DATA PLACED INTO EXCEL FORMAT
SCAN DENSITY IS 12.5 MICRONS X 12.5 MICRONS (CONFIGURABLE)
TIME TO ACQUIRE DATA IS APPROXIMATELY 0.04 SECONDS
PASS / FAIL CRITERIA: PIN HEIGHT AT 4.0MM +/- 0.2MM

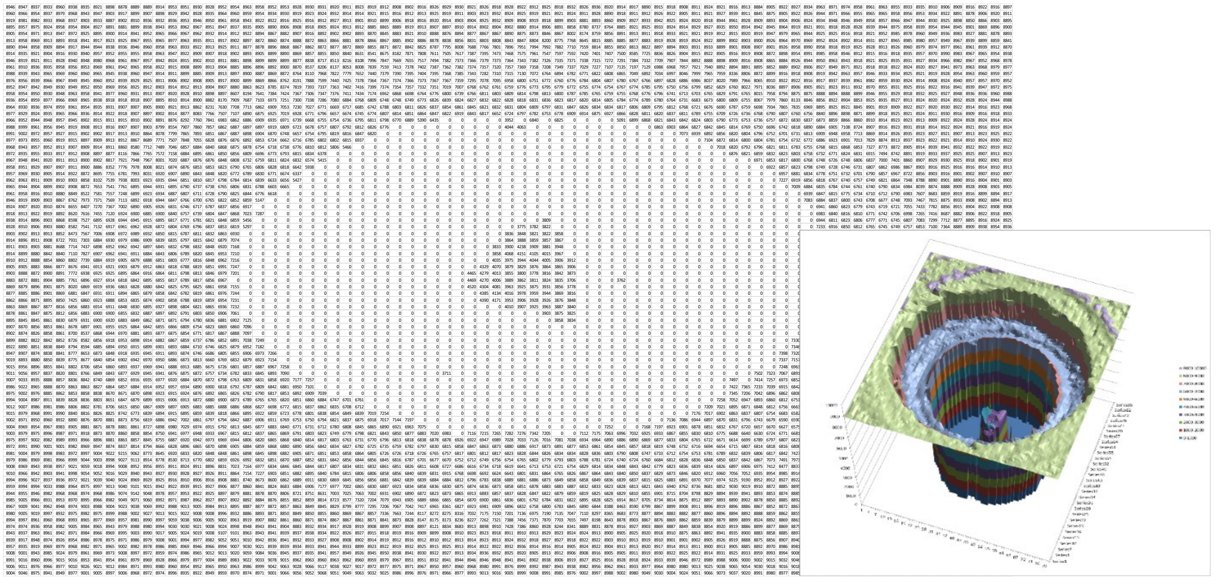

Figure 15. 3D Profilometer inspection of a pin hole (Courtesy of Toptest)

Testing Challenges

Orthogonal Systems

A related trend in the connector industry has been toward systems utilizing an orthogonal architecture. These systems feature pin headers, pressed on both sides of the board, which share signal vias when used on an orthogonal mid-plane. This represents a growing market segment particularly in backplane designs for high-speed digital communications', shared-via mid-plane architecture creates a unique challenge for inspection of the press fit interface. Vision inspection of the compliant pins is not possible. Electrical testing can be unreliable, as certain press fit failures may pass this test by contacting the top of the PTH barrel. Modern robotic X-ray inspection methods are now much more effective but can still be dependent upon the manner and resultant shape of the press fit failure.

Connector Compliant Pin Continuity and Resistance

Bed of Nails, Flying Probe and Fixtures remain the predominate method to check electrical continuity and isolation resistance for press fit connections onto the printed circuit boards.

High speed communication and signal integrity Testing

There are many press-fit problems that would not be detected using a DC contact resistance measurement but would still represent a huge connection loss on a multi gigabit per second digital signal. The expected trend is for the digital transmission speed requirements to continue their increase. This is a current, very real and growing problem for the industry. Some of these can be detected using X-ray inspection (such as bent under pins), others cannot.

It is well established and widely published that TDR and S parameter measurement can easily detect press fit faults such as the examples in Figure 16.

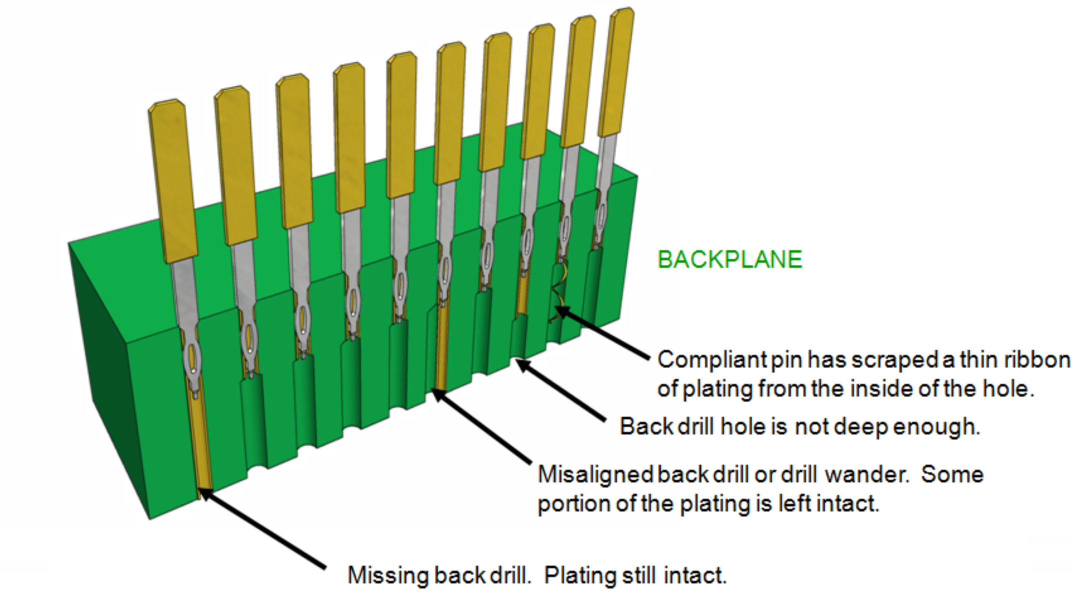

Figure 16. Cross Cutting: Press Fit Pin Testing Forecast

(Courtesy of Robat)

An example of TDR is in figure 17 which shows the TDR reflection from a single bent under pin on a GBX press-fit connector.

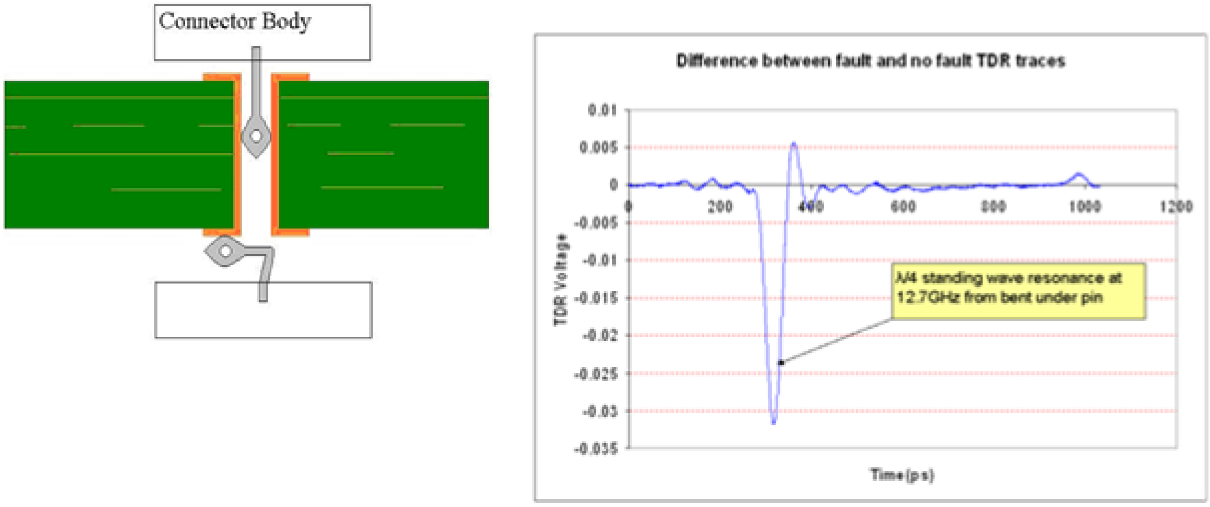

Figure 17. Example of Bent Pin with TDR Data

(Courtesy of Robat)

Systems do exist for automatic testing of bare board traces and sample coupons using TDR/TDT. But these systems cannot currently be used for routine automatic testing of fully assembled boards. The industry need is for an automatic production test method for backplane PCB's, including orthogonal and mid-plane nets, which is fully scalable to deal with large samples.

The other real and growing problems in the press-fit interconnect system for high integrity requirement is environment control. Particles or fibers from raw material, manufacturing, or the user environment in a DIMM socket pins and circuit board contact pads can be observed from time to time. These foreign materials can create a barrier for proper contact between pad and socket. To avoid the accumulation of fibers and particles on contact pads, there are many changes required in environment control and management for sensitive interconnects devices such as press-fit pins and optical modules. The use of particle counters is getting popular in particulate control in manufacturing floor along with connector vacuuming, cleaning and re-seating/insertion of an edge card.

Real-time particulate monitoring study of two facilities across the Pacific Ocean indicated that particulate control and management alone are not enough to totally resolve the memory card re-seating DPPM (Defective Parts Per Million) problem. There is a DPPM of several thousand for DDR socket fall out at system level testing which cannot be resolved by process control such as contact surface cleaning, particulate vacuuming, re-seating and particulate management in manufacturing environment. Therefore, an alternate interconnect methodology may be needed to resolve the interconnect challenge. A new generation of dual-contact interconnect DDR sockets can be a potential solution for more robust interconnect, which are in the development and verification stage.

Signal Integrity Testing development

There have been some significant developments recently with machines for carrying out automated Signal Integrity testing.

The challenge with any high-speed measurement equipment (particularly TDR equipment) is to try to place the equipment as close to UUT as possible in order to reduce cable length and therefore obtain cleaner (less 'noisy') TDR measurements. Early robotic equipment placed the TDR measurement units in a fixed location. This involved connecting reasonably long cables from the units to the UUT interface. Multiplexing methods were used to distribute the TDR measurement signal to multiple test pins without excessive motion (as in a flying probe), making this test solution a viable alternative in a production environment. Follow on generations of equipment have the TDR measurement units fitted progressively closer to the UUT resulting in significant reduction in the cable length (up to a factor of 6); the effect has been a big jump in performance.

The evolution of this type of equipment continues as the latest generation machines now have bespoke 24 port TDR units and total elimination of all multiplexers and switching.

OEM's designing the latest high-speed backplanes will say their ultimate goal is to have a complete fully automatic functional test of their boards in the fastest time possible with as little dedicated tooling as possible. To carry out this high-speed functional test requires taking measurements in the frequency domain using a VNA (Vector Network Analyzer). Frequency domain measurements dictate that each end of the net must be connected simultaneously to the VNA. To achieve this via a fully automatic method, requires a machine to have four independently controlled robotic heads to enable nets that either start and finish on the same side of the PCB or start and finish on opposite sides of the PCB to be contacted simultaneously – see diagram in figure 18 below.

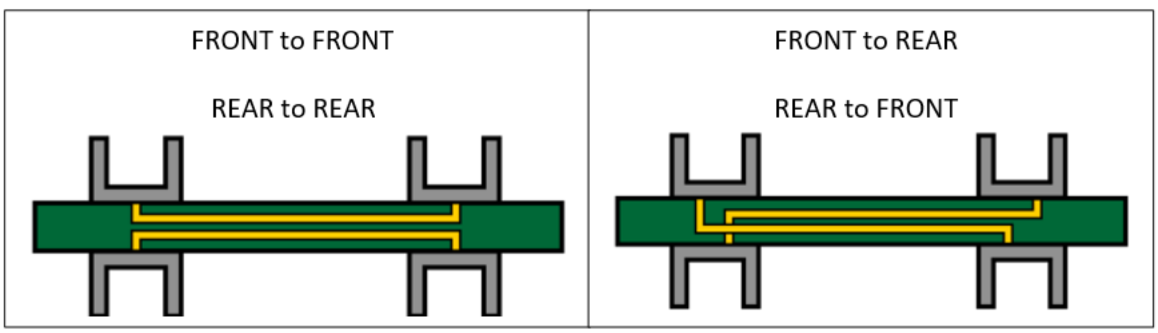

Figure 18. Possible Test Scenarios using a VNA

(Courtesy of Robat)

Other current developments with SI testing are application based:

<u>Bare Boards</u>

Approximately 50% of the faults found during the TDR test of an assembled backplane are bare board manufacturing faults. Because of this there is a growing requirement/demand for 100% fully automatic TDR/VNA test to take place at the bare board stage.

Line Cards (or Daughtercards as they are sometimes known)

High speed Line Cards typically use the same press-fit compliant pin technology for the right-angled edge connectors as can be found in the straight connectors used on backplanes. Inevitably, they can suffer from the same faults. Again, as with the requirement for Bare Board SI testing, there is a growing demand to take TDR measurement through the right-angled connectors on a Line Card.

PCB Type	Description	Available Now	Available in < 6 months	Available in > 6 months
Backplane	Fully Automatic TDR Test with 24 Port TDR Unit	✓		
	Fully Automatic TDR Test with 24 Port TDR Unit capable of TDT (4 heads)	□	✓	
	Fully Automatic VNA Test capability (4 heads)			✓
Bare Board	Fully Automatic TDR Test with 24 Port TDR Unit		✓	
	Fully Automatic TDR Test with 24 Port TDR Unit capable of TDT (4 heads)		✓	
	Fully Automatic VNA Test capability (4 heads)			✓
Line Card	Fully Automatic TDR Test with 24 Port TDR Unit	✓		

Table 2. Summary/Availability of Fully Automatic SI Test functions/Applications
(Courtesy of Robat)

Repair

Contract Manufacturers are challenged by many different connector types and rework methods required to remove pins, wafers and connectors. Many assembly sites use pliers to pull the pins, wafers or housings even though most connector companies sell repair tooling. The need for connector manufacturers to design in unique features to allow easy removal, while preventing damage to the PCB, is encouraged, and common tooling to rework connectors is suggested. Connector bodies need to be designed for removing the connector, as well as placing it. Strategically located tooling holes or features for removal tools need to be designed into the housing. Also, the mechanical strength of the body should be sufficient to allow removal of all pins at once without mechanical failure of the body. Compliant Pin Press Fit rework remains at 2 max insertions of a new pin after the initial press.

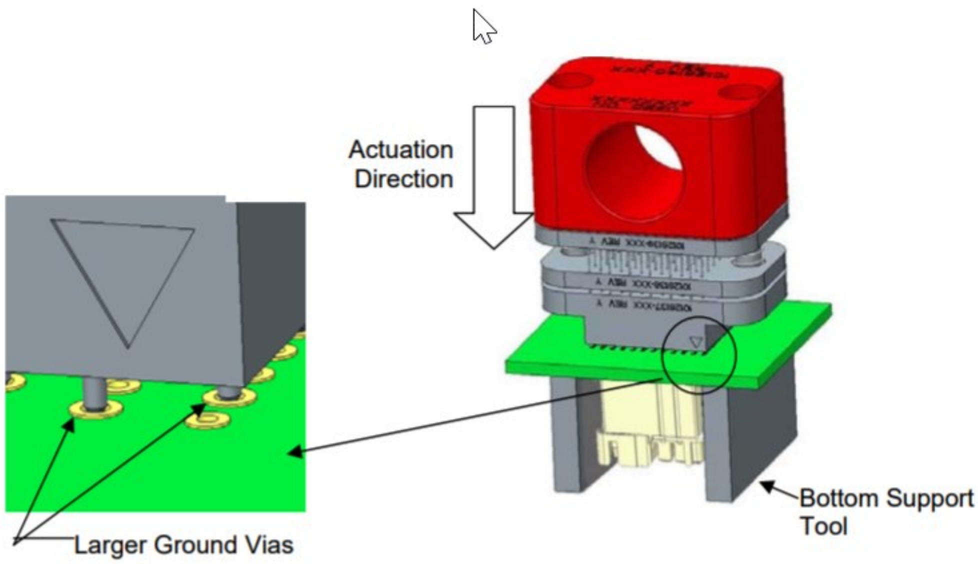

Figure 19. Connector removal tool

(Courtesy of Amphenol)

In effort to enhance the Press Fit Pin and Connector installation, rework process steps, new Connector designs shall incorporate the following considerations or information:

- Basic Connector constructions should consider and allow simple rework such as single Press Fit Pin, Wafer, Segments and/or Guide Pins.
- Tooling methods should be devised for basic insertion and removal processes.
- Insertion and removal tools shall incorporate precision clearance and relief of surface mounted components around housing.
- Simple true position datum point and reference markers for male pin inspection will aid optical or light inspection methods.
- Connector housing Feet or standoff features need to allow some free space for surface features to aid inspection and quality verifications.
- Evaluate and release data on multiple rework cycles thus allowing more than 3 insertions of a new compliant pin into same hole. (High Speed Pins have low PTH deformation while Power Pins have higher deformation), not yet any data submitted to EIA and IEC.

Environmental Requirements

Despite the current RoHS exemption allowing lead in compliant pins, the marketplace remains largely divided between tin-lead and pure tin for connector pin plating. This market division requires connector manufacturers to maintain dual part numbers (and inventories) for tin and tin-lead. Additionally, the removal of lead from PCBs has posed challenges for press fit pins. While a tin-lead PCB surface finish continues to be common on those products not required to be RoHS compliant, many OEMs have migrated to the use of Immersion Tin, Immersion Silver and OSP surface finishes. While pin insertion and withdrawal forces vary slightly with the type of surface finish used, lead-free plating types tend to cause an increase in the compliant pin insertion forces. These increased forces due to the surface finish can reduce connector installation success, particularly with FHS below the nominal specified diameter.

Tin whiskers so far have not been a primary concern on products using the Immersion Tin surface finish.

Prioritized Research & Development

- Compliant Pin Eye of the Needle Cracks: our TWG encourage Connector Manufacturers and OEMs to further study and evaluate the impact and acceptability of this condition upon specific products and end use conditions.
- Standardize trays and tubes for automation.
- Determine threshold as to when automated Connector, Pin placement and inspection is required. Justification as to when automatic machines are required for connector pick, pin inspect, place and press process steps. Accurate pin placement and tail inspection of the connectors is needed.
    - As the industry becomes even more cost competitive, connector pins and PCB PTH's get smaller, this need will become more pronounced in order to improve throughput and yields. One of the first steps in automating the process is to standardize the connector trays between companies for the machine.