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Micro ACTION PIN Compliant-Pin Connectors:
Advancing the State of the Art in Press-Fit Technology

INTRODUCTION

Micro ACTION PIN (MAP) connectors from Tyco Electronics have taken through-hole connector technology to a new level—significantly reducing hole diameters compared to previous designs, while retaining the assembly and operational advantages of press-fit connectors. Equally important, the inherent design attributes of MAP connectors offer electrical performance comparable to, or better than, connectors employing surface-mount Ball Grid Array (BGA)-type attachment.

This white paper briefly reviews the salient electrical and mechanical characteristics of this latest evolution of ACTION PIN connector technology.

THE EVOLUTION OF ACTION PIN CONNECTORS

ACTION PIN connectors from Tyco Electronics, originally developed for multi-layer PCB applications in the 1970s, have experienced steady miniaturization through the present day (Figure 1). The original devices, designed for Eurocard connectors, featured pins designed for 1.5 mm finished holes. The unique design of these compliant pin, press-fit contact tails was given the name "ACTION PIN" contact. The latest version of this evolution—the Micro ACTION PIN contact—provides this same robust mechanical and electrical connection to circuit boards with finished holes just 0.22 mm in diameter (Figure 2).

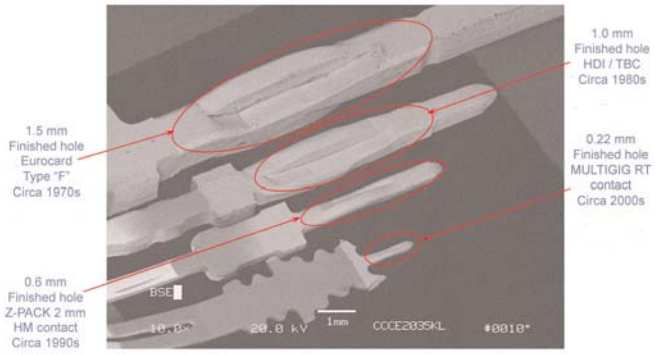

Figure 1: The evolution of the ACTION PIN press-fit connector pin from the 1970s to the present shows a steady miniaturization trend.

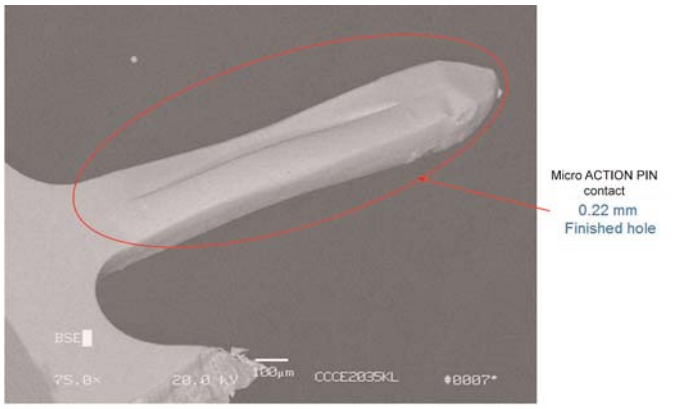

Figure 2: ACTION PIN contact topology is retained in the smaller MAP pin.

The introduction of Micro ACTION PIN contact topology now makes it possible to produce high-density connectors (Figure 3) suitable for very high frequency interconnections between mother board and daughter boards and/or mezzanine boards, I/O boards and even backplanes. The presumption that surface-mount attachment of connectors would be required in some of these high-performance applications is no longer true.

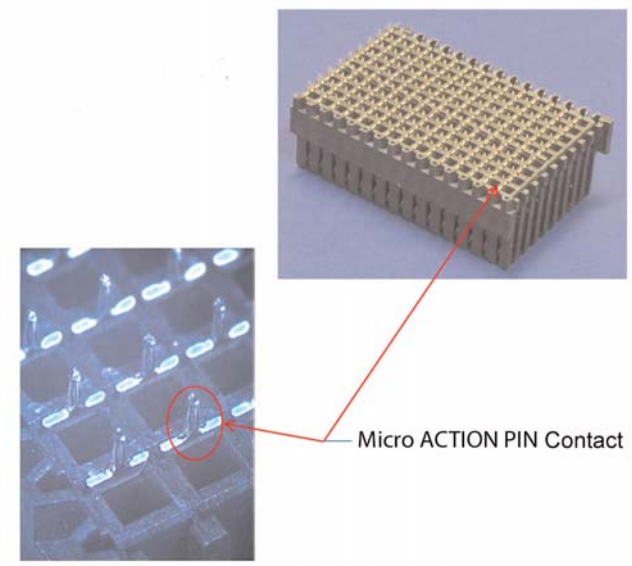

Figure 3: An example of a high-density MAP connector. This connector configuration was used in the analysis reported in this paper.

KEY ELECTRICAL FEATURES AND BENEFITS

Signal Integrity

Because ball-grid array (BGA) attached connectors are still considered the benchmark topology for electrical performance, the electrical data provided by the MAP connectors were measured against comparable surface-mounted BGA connectors. Figure 4 depicts the topology of the two test boards, each consisting of 0.30 mm drill, 0.56 mm pads and 0.81 mm antipads. The comparative electrical data shown in Figure 5 indicates generally similar results in terms of insertion loss, but the MAP connector shows a marked improvement over surface-mount type in terms of impedance.

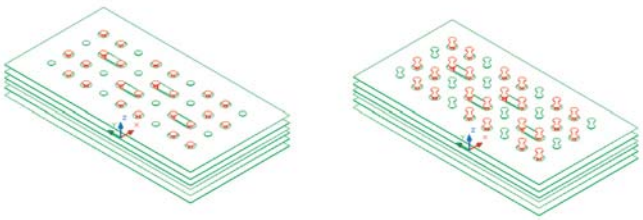

Figure 4: Dual board set-up for testing the electrical characteristics of comparable Micro ACTION PIN press-fit connectors (L) and BGA via off pad connections (R).

The conventional wisdom that press-fit connectors cannot offer the same degree of electrical performance as surface-mount connectors is now being challenged by Tyco Electronics' Micro ACTION PIN contact technique. MAP connectors have consistently demonstrated equivalent or better electrical performance without the mechanical problems associated with surface-mount attachment methods.

One of the main performance advantages of surface-mount attachment methods has been the smaller diameter via that typically produces higher electrical performance. However, the Micro ACTION PIN contact's reduced hole diameter, coupled with the elimination of the solder pad required by surface-mount methods, results in more consistent electrical performance. In Figure 5, the differential impedance plot of the surface-mount connector displays a significant dip caused by capacitance of the solder pad. The relatively stable impedance of the MAP connector, which requires no solder pad, more closely approximates the desired nominal value of 100 Ohms. The data shown in Figure 5 effectively dispels any preconceived notion that press-fit connectors cannot meet, much less exceed, the electrical performance of surface-mount attachment methods.

Improved Circuit Design Flexibility

The MAP contact's greatly reduced plated-through-hole (PTH) diameter versus typical press-fit products increases flexibility for board designers by allowing use of wider traces with lower tolerances and, where appropriate, dual-trace pairs, or quad routing, in lieu of single-pair traces. Despite the high degree of precision inherent in quad-routing, manufacturability of board traces employing the MAP connector has been demonstrated to be well within the fabrication capability of typical PCB manufacturers.

As an alternative to quad-routing, MAP connectors afford designers the option of employing wider-than-typical traces that can either boost overall system performance or allow use of lower-cost PCB materials.

Minimal Electrical Stub

Compared to other press-fit connector technologies, the length of the MAP pins is much shorter.

The shorter pins (Figure 6) provide the opportunity to reduce the electrical stub in the thru-hole to a minimum by increasing the depth of the counter-bore in the plated through holes.

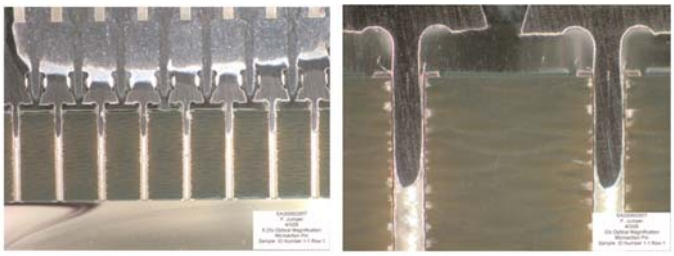

Figure 6: Minimal electrical stub of the MAP connector shown at left, and close up at right.

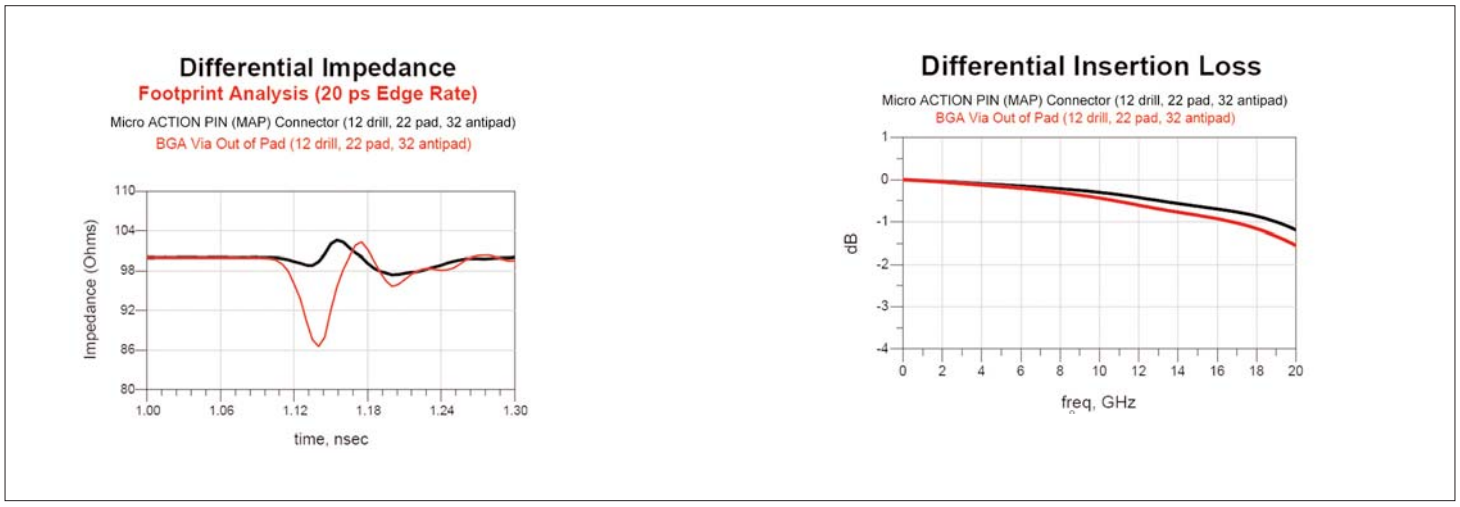

Figure 5. Electrical performance comparison between MAP and BGA connectors

KEY MECHANICAL FEATURES AND BENEFITS

Compliance with Standards

EIA 364-96 & IEC 60352-5 standards require radial hole distortion measurements of less than 37.5 µm and 70 µm, respectively. These standards likewise specify allowable remaining copper plated wall thickness. EIA364-96 permits no breakthrough, whereas IEC 60352-5 requires greater than 8 µm remaining wall thickness.

As shown in the MAP connector cross-sections in Figure 7, both the radial hole distortion and the remaining wall thickness are shown to be well within the most stringent standard.

Connector Removal / Reinstallation

As the data in Table 1 indicates, with the application of a uniform unmating force, it is possible to remove a MAP connector from the printed circuit board. Laboratory tests have demonstrated that three such insertions and re-installations can be performed without materially affecting the electrical or mechanical performace of the connector.

In this way, MAP connectors offer an extremely easy and manageable repair process, if needed, as opposed to soldered BGA connectors that are extremely costly and problematic to remove and reattach.

Average of 10 Samples	Board Vendor A	Board Vendor B
Insertion Force (pounds, per contact)	3.69	4.43
Retention Force (pounds, per contact)	2.50	2.86

Table 1. PCB Performance Test Results

Compatible with Simple "Flat Rock" Tooling

Two critical parameters associated with press-fit connectors are the amount of force required to drive the pin into the hole and the surface area (shoulder) of the pin required for contact with the driver housing. Higher insertion forces logically require more shoulder surface area, which typically results in a performance-reducing electrical stub. Another problem caused by large-shouldered connectors are thinner plastic walls that are more difficult to mold and tend to crack easier.

Alternatively, MAP connectors are compatible with simple "flat rock" tooling, due to their low insertion force and minimal shoulder. Once the MAP connector pins are located over the array of holes on the printed circuit board and the flat-rock tool positioned on the connector, uniform pressure applied by a simple press is all that is required.

Many connector styles today, like typical pin headers that require intricate tooling, will benefit from the Micro ACTION PIN contact approach, leading to simpler connector designs, wider application of flat rock tooling methods and and easier implementation.

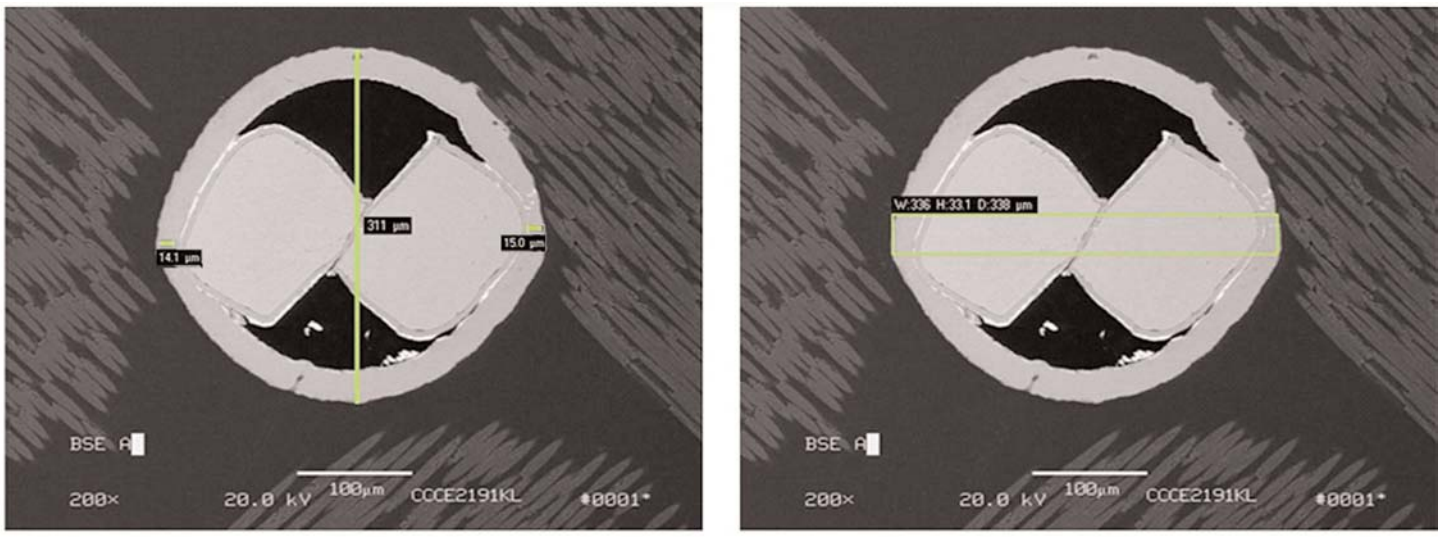

Figure 7: MAP connectors meet or exceed corresponding EIA and IEC radial hole distortion and remaining wall thickness requirements. The images (L & R) show x-axis and y-axis diameter differences of just 27 µm. The left-hand image also shows the mimimum wall thickness to be 141 µm.

Test Group	Test Results
Temperature-Humidity	Met requirements for LLCR, mating/unmating, IR, DWV (Mated and unmated samples)
Temperature Life	Met LLCR and mating/unmating force requirements; no discontinuities during shock/vibration tests
Mixed Flowing Gas	Met both LLCR requirements (mated and unmated samples)
T-Rise (Current Carrying)	Connectors passed 30°C max T-rise requirement (mated samples)
Compliant Pin Insertion/ Retention/Radial Hole Distortion	Met requirements for insertion (7.5 lbs, max) and retention (0.5 lbs, max) forces; radial hole distortion (0.037 mm, max) and remaining copper thickness (0.008 mm, min)

Table 2. MAP Connector Performace Testing

MICRO ACTION PIN CONTACT TESTING RESULTS

Recognized standard test sequences were conducted to evaluate the characteristics of the MAP connector alone (unmated) and also when plugged into its mating receptacle. The test devices met all requirements for low-level circuit resistance (LLCR), insulation resistance (IR), dielectric withstanding voltage (DWV), as well as other characteristics shown in Table 2.

CONCLUSION

For high-density applications, Micro ACTION PIN connectors—based on existing press-fit technology—have taken through-hole connections to a new level. MAP connector technology represents a quantum technical leap forward, providing durability, ease of manufacturability and electrical performance that is superior to existing press-fit connector technology and more than comparable to surface-mount techniques.

SOURCES

[1] Morgan, Chad W. “Transition to Surface-Mount: An Analysis of Signal Integrity Improvement versus Manufacturing Concerns in Multi-Gigabit Systems Using High-Density Connectors.” Euro DesignCon 2004 TE3C, Harrisburg, PA.

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