DESIGN CONSIDERATIONS WHEN SELECTING NANO INTERCONNECTS FOR ELECTRONIC APPLICATIONS

Introduction

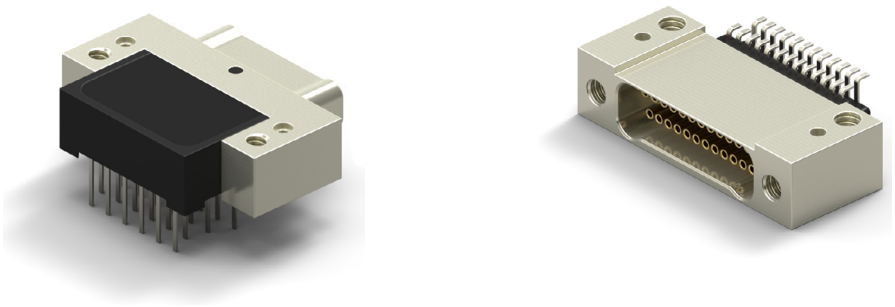
The evolution of miniaturizing electronic connectors has dramatically increased over the last several decades. It remains fueled by industry expectations for a reduction in board packaging along with space and weight savings. Today's sophisticated, reliable rugged electronic systems and subsystems have continued to shrink in size and weight, but not in features that require more signal paths. The traditional "go to" interconnect solutions such as M38999 and D Subminiature connectors commonly used in defense electronics are simply too big and heavy to satisfy new design requirements. As the evolution advanced, M83513 Micro D connectors were designed in the 1960's, followed by 0.025" centerline style Nano's in the 1980's. MIL-DTL-32139 for Nano connectors was finalized in 2003. The use of Nano circuit connectors has become increasingly popular and growing in total percentage of the connectors processed in various PCB applications. These high-density connectors are available in through-hole and surface-mount versions with advantages and disadvantages to both. This paper summarizes some of the key considerations when choosing the right board level Nano connector on a 0.025" pitch.

Through-Hole vs Surface-Mount Termination

As board level connectors get smaller, they tend to become more difficult to process. Yet these Nano connectors still need to be mechanically robust to withstand challenging conditions on the assembly line, as well as the harsh environment it's likely to wind up in, such as high shock and vibration conditions. Printed circuit board connectors are available in through-hole or surface-mount versions. Both are used in ruggedized electronics systems and subsystems, ranging from avionics, UAV's and missiles, to instrumentation and solder-worn radios and equipment.

The use of Nano connectors has become prolific in these complex systems. Through-hole connectors require holes to be drilled in the PCB so that the leads of the connector can penetrate the board and be soldered from the bottom to form a connection with the PCB. Through-hole connectors typically require manual mounting, or sophisticated robotic placement. The advantage of through-hole technology is that it is historically more reliable. The disadvantage is it consumes a considerable amount of PCB real estate.

Conversely, the leads of a surface-mount connector are installed on the same side of the PCB, therefore freeing up space on the underside for other component mounting, such as semiconductors, capacitors, resistors, etc. This allows the ability to fit a high number of small components on a PCB, affording much denser, higher performing, and smaller PCB's. Surface-mount connectors can also be installed using the same pick and place equipment as the other surface-mount components, which offers a significant time and cost savings.

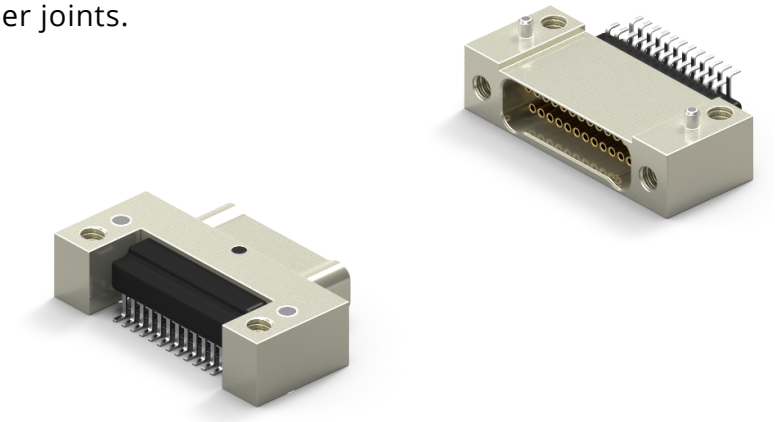


Nano Connectors shown with Through-Hole Leads and Surface-Mount Leads

Packaging and Processing Surface-Mount Nano Connectors

The key challenges with high-density Nano connectors are predictability of processing and component robustness. For processing, hand soldering or the use of a hot bar is still common in low volume production. For higher volume production runs, most surface-mount Nano connectors are packaged in tape and reel or plastic trays formed specifically for the product. This type of packaging can support pick and placement by automated handling equipment using vacuum nozzles. With the introduction of RoHS, while not a common practice with military electronics; tin/lead solders are replaced with pure tin or with a gold plate, which require higher reflow temperatures. In many cases, plastic connector materials were upgraded to Liquid Crystal Polymers and Polyphenylene Sulfide, capable of resisting deformation at elevated reflow temperatures.

Design Engineers need to be sure the connectors can be reliably terminated with a consistent, predictable process. Accurate alignment of the surface-mount contacts to the solder pads is also extremely important. Additional locating features can be beneficial, to insure the surface-mount contacts are positioned properly, and are in physical contact with the high-density solder pads to create a proper solder fillet. This is particularly important for high end applications requiring IPC-A-610, Class 3 solder joints.



Nano Surface-Mount Connectors shown with Solder Alignment Posts installed

The Connector / Printed Circuit Board Interface is The Key to Success with Nano Connectors

The Nano contact system is a size 30 and is a “reverse gender” system. That means the pin contact is fully recessed within the cavity of the insulator and is the compliant spring member that engages with the socket tube, which is typically machined, drawn or stamped. The tight tolerance of this contact system is what allows it to withstand the severe shock, vibration and/or acceleration that is common in high end military electronics. There is a significant amount of design latitude in meeting the performance criteria, however not all contact designs are identical. All who manufacture to the M32139 specification are supposed intermate and they typically do, however not all Nano contacts are manufactured the same.

While there are variances in the compliant section of the male pin, all perform in accordance with the MIL-DTL-32139 specification. For example, one of the earliest contact designs is the Twist Pin which is still being manufactured. This contact uses a twisted wire bundle that has been cut, coined then welded at the tip. Then crimped into a barrel, which is then crimped again to a solid round copper wire. Finally, that wire is formed into a round surface-mount contact tail. The basis of any functional design process is repeatability. Discrete contacts such as the Twist Pin are manufactured one at a time using multiple process, (cut, coin, weld, and crimped twice) to yield a single contact which is fed into a vibratory bowl to be crimped to the round wire used to form a surface-mount contact tail. The alternative for manufacturers of M32139 contacts is to use a stamped contact from a progressive die, so the compliant section and the contact tail is integral to the entire stamping, which eliminates the need to crimp to a solid wire. This process effectively eliminates all crimp resistance issues as well. The stamping process guarantees consistency of design and more importantly assures quality control.

The socket design criteria is the same. The base material is generally a copper alloy, or BeCu, and the machined, drawn or stamped barrel is what engages with the compliant pin. The surface-mount tail on the socket is integral to the barrel, which facilitates uniform, tight tolerance forming and eliminates all crimp resistance.

Twist Pin Design vs. Stamped Compliant Pin Design

Socket with Crimped Round Surface-Mount Lead vs. Socket with Integral Tail Surface-Mount Lead

Coplanarity is Critical to Creating a Reliable Surface-Mount Solder Joint

There is a continued push toward the use of small form factors like Nano connectors, in spite of the difficulties in processing many of them. Early on, the reject and scrap rate of surface-mounted components, Nano connectors in particular, was horrendous. The inconsistency of contact coplanarity was prolific and was perceived as an industry wide problem. Because of this major concern, many engineers were reluctant to use Nano connectors in their circuit designs, in spite of the obvious space savings.

Quality is always a primary concern, it becomes even more important in surface-mount and Nano applications. Tolerance build up that was allowable with through-hole technology is no longer acceptable when processing 0.025" centerline connects. As a result, there are now additional considerations that need to be addressed in these applications. At the top of the list is coplanarity and registration of the male and female surface mount contact to the solder pad. Coplanarity of Nano connector contacts directly affects the robustness of the solder joint. Ideally all leads should lie in the same plane because if any of the leads are significantly higher or lower than the plane, it will likely lead to open solder joint. Which then takes the assembly down the expensive path of re-work or scrap.

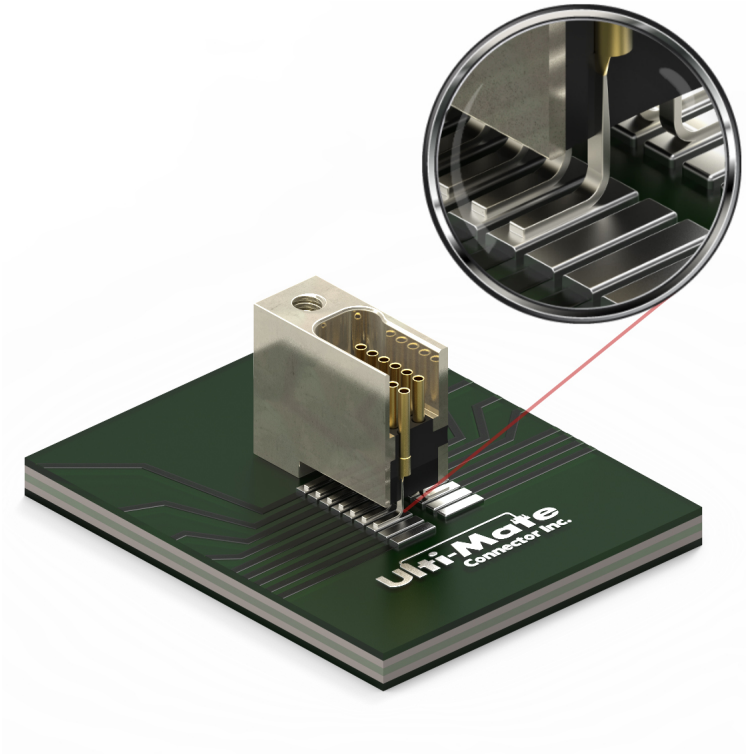
Flat Leads vs Round Leads

IPC standards have long recommended the use of flat leads for surface-mount applications, and that remains the preference of most major military contractors. Round male and female leads cause variations in tail dimensions and misalignment, leading to solder issues. Round wire leads also contribute to accidental bending during set-up preparation and handling.

Ulti-Mate Connector Inc. is the only manufacture to successfully solve this problem by developing both a one-piece flat lead, pin and socket Nano size 30 contact, with a thickness of 0.005" x 0.010". Their surface-mount design and proprietary process, allows for a coplanarity of 0.000" to 0.003", which is identified on the drawing. This provides the assurance of high quality solder fillets, thus reducing cycle rework time significantly, in one case by as much as 62%. Other Nano manufacturers are only able to provide the male pin as a one-piece contact with a flat tail, however the tail thickness is only 0.0025" which is very fragile, hard to control and difficult to package without causing damage.

Conclusion

Not all Nano contacts are created equal. Precision formed pin and socket contacts with integral, thick one-piece surface mount leads are the most reliable solution to today's design requirements while developing sophisticated ruggedized military, space, avionics, medical devices and down-hole tools.



Nano Surface-Mount Connector Cross-Section showing Contact Coplanarity of 0.000" to 0.003"

By: Greg Jones & John Buzoianu

Ulti-Mate Connector Inc. has been producing world-class connectors and customized solutions since 1977. From our facility in Orange, California we proudly serve the interconnect needs of the Military, Aviation, Medical, and Geophysical markets. Our reputation for innovation and quality has placed Ulti-Mate Connectors in advanced missile and guidance systems, predator drones, unmanned satellites, directional drilling equipment, and medical imaging systems.