Problem Solving with the PCB Co-Planar SMT Connector

Surface Mounting is the fastest growing technology in electronics today. This is due first to the great potential for assembly cost savings generated by the increase of PCB component density, board surface utilization and routing density, and secondly, to the elimination of board damage factors such as fiber fracture, friction forces of pin insertion or trace distortion.

Certainly, solder joint reliability issues increased with the shift of the through-hole towards re-flow technology. Solder joint robustness characteristics decreased and it is usually much more difficult to maintain, especially from the standpoint of the CTE (Coefficient of Thermal Expansion) variations.

Since the TB (Terminal Block) type of interconnect products are frequently larger than the other passive or active elements, the mechanical properties of the solder joint are less reliable for SMT applications compared to the THWS (Through Hole for Wave Solder) or THR (Through Hole Re-flow) applications.

Regarding miniaturization, the TB interconnect could not follow the improvement at the same pace as it was for the majority of other components for SMT applications.

However, an important miniaturization proportion can be assessed for the last decade: spacing between adjacent contacts was reduced to 3.5 mm. Finally, design complexities related to the adaptation of TB interconnect to the SMT environment is considered to have been more difficult compared to other passive elements because of installability constraints.

A Pareto analysis of SMT related TB interconnect mechanical problem situations indicates the following causes generating the majority of problems in terms of solder joint reliability: assembly process issues and installability.

1. Co-planarity of the connector leads to ensure adequate contact to the PCB pads.
2. CTE (Coefficient of Thermal Expansion) mismatch between the plastic housing material of the TB and the PCB material.
3. Inadequate connector hold-down/retention to withstand mating or field installation stresses.

This article will focus on an original engineering realization that solved both problem items 1 and 2 through the design and introduction of the PCB co-planar adaptable SMT receptacle connector (Patent Pending). It is believed that the impact of this concept will be considerable at the SMT utilization level since the dynamic property of total adaptability of all the electrical contacts has been practically demonstrated. Zero co-planar tolerance performance is the principal characteristic of this new generation of SMT connectors. In other words, the property of the pin to adapt itself to any type of PCB bow, irregularity or variation and in any assembly situation totally eliminates the co-planarity concern.

Figure 1 illustrates a failed solder joint due to a poor co-planarity factor of 0.4 mm. Figure 2 illustrates the capacity of co-planar adaptation of WECO’s 120 M 221 SMD receptacle connector (patent pending) with electrical contacts (pins) compensating a 0.45 mm PCB bowed situation.

The second major benefit of the PCB co-planar adaptable SMT receptacle connector is the practical elimination of the CTE mismatch (problem 2) that creates important damage situations for connectors containing fixed pins (see in Figure 3 as an example of an SMT pin fixed into the body of the plastic housing). We computed that for a PA46 material with 30 percent glass fill used for thermo resistant connector housing including 24 fixed SMT pins, aligned as per a 0.15 mm co-planarity criterion, a relative expansion of approximately 0.1 mm measured between the extremities of the connector after 30 seconds of convective thermal exposure to 265°C, could have been produced.

This expansion factor of plastic material would normally produce considerable stress on those fixed SMT pins. For SMT contact pins having a larger co-planarity tolerance factor (for example, >0.25 mm), important solder fractures could appear at solder joint level. The explanation for this potential damage assessment is due to the difference between the CTE factor for PA46 material (CTE = 36) and PCB material (FR4 with CTE = 17). In other words, the PA46 material that includes the fixed SMT pin expanded faster than the PCB itself.

This expansion, followed by material contraction after the re-flow process, produces a considerable stress at solder joint level for fixed SMT pins. The higher the co-planarity gap for an SMT pin, the more important the damage risk factor at solder joint level. One natural problem-solving conclusion is that SMT interconnect-related CTE mismatch can be eliminated only if the SMT pin gets sufficient freedom of movement to adapt itself to the expansion and subsequent contraction of the plastic housing.

The solution to both problems 1 and 2 were obtained from the conception of a special SMT mountable contact pin with a 3D degree of freedom and so to compensate the inherent planar variations of the PCB (problem 1, OZ axis), or the expansion of the plastic housing (problem 2, gap between housing and pin). The movement freedom of the co-planar adaptable pin is shown in Figure 4.

The idea itself is simple, consisting of a pin with a smaller diameter than the dimensions of the housing hole capturing it. However, the key conceptual element that had to be designed was its retention capability within the connector housing. This feature of the connector to retain its row of contact pins enables it to work normally under mating and un-mating installation conditions without removing from its free movement degree within the retaining cavity.

Without detailing the mechanical construction of the self-locking contact pin itself, it can be mentioned that it includes three distinct portions. Once inserted through the hole of the connector housing, it gets locked but maintains the property of dynamic adaptability to planar variations. Depending on the configuration of the PCB surface and the re-flow heating environment, it can compensate for any PCB surface variation and thermal expansion. Contraction of the plastic housing will not affect the robustness of the SMT solder pad because of the freedom degree of the pin. A cross section into a PCB co-planar adaptable SMT receptacle connector containing self-locking adaptable contact pins is shown in Figure 5.

Connectors containing self-locking adaptable contact pins have been tested with exceptional results in relation to SMT performance specifications.

- One hundred percent Co-planarity is achieved. PCBs that bowed after the re-flow process by 0.5 mm still provided perfect contact characteristics at solder pad level. This exceptional performance was due to the OZ adaptability of pins (See Figure 2).
- No damage was observed at solder joint level due to CTE mismatch. This exceptional performance is due to the freedom degree of the self-locking pins inside the housing.
- The solder retention resistance of one single self-locking contact pin is extremely high. A typical value is 2 lbs. per pin. Multiply this value by the number of pins and get the SMT retention value for the entire connector.

In conclusion, it is believed that a connector equipped with SMT self-locking adaptable contact pins fully solves both co-planarity and CTE mismatch problems which currently constitute major obstacles for interconnect products using fixed SMT contact pins.

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