Printed Board Assemblies Test Coverage Calculation: New Calculation Method

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Abstract

There are three ways that major industries use to calculate Printed Board Assemblies Manufacturing Test Coverage. The problem with these methods is that they combine parameters that are either relative to inspection or testing to provide an overall Test Coverage. This may lead to misinformation and making wrong decisions such as removing inspection or test steps due to complacency with Test Coverage results. A survey was performed to understand better which method is being used and the needs the users have. To generate a new method of calculating the Printed Assemblies Board Manufacturing Test Coverage, the results were analyzed, requirements were established, and a new method was designed. A way to test this method needs to be generated using the Printed Board Assembly Complexity Index.

Introduction

When calculating Printed Board Assemblies Test Coverage often Test Engineers encounter issues when explaining overall test coverage to other Engineers or Management that are not often involved in manufacturing or test processes. The three major formulas to calculate PBA Test Coverage Assemblies combine parameters that are either related to testing or inspection. The researcher wanted to develop a new way to calculate PBA Test Coverage that would avoid misunderstandings and the removal of necessary steps during PBA Manufacturing.

Background

"When asked, many Engineers will say that the goal of a Test Plan for a PCB is 100% test coverage. When pressed further, they usually admit that 100% test coverage is virtually impossible to achieve" [3]. Calculating the Printed Board Assembly Test Coverage requires understanding of the PBA complexity, manufacturing test processes, possible defects and test methodologies. Different Test Methods can be tailored depending on the manufacturing processes to optimize the capture of possible defects. Automated Optical Inspection (AOI) can be used post pickle and place and during pre or post flow. Automated X-ray Inspection (AXI) pre or post wave. In circuit Test (ICT) only after post wave [1].
The main inspection and test methodologies used across industry are Manual Inspection, AOI, AXI, Boundary Scan Testing and ICT. The first three can be classified as Process Monitoring and Structural Test and the last two as Electrical Structural Test [3]. To be able to perform ICT or Boundary Scan testing, access is needed. Test access continue to be an issue since may lower down PBA Test Coverage, especially for in circuit test, which is fundamentally dependent on electrical access [2].

Problem

The researcher investigated the issues encountered with the current Printed Board Assemblies Test Coverages by:

- Developing a method to calculate PBA Manufacturing Test Coverage that separates Inspection from Testing
- Differentiating Inspection and Test methods
- Understanding possible failure modes of electronic parts used on Printed Board Assemblies

Methodology

A survey was prepared to understand better how these methods are used and the current needs. The results were carefully reviewed and used to create a new method of calculating the Printed Assemblies Board Manufacturing Test Coverage. The questions included in the survey were:

- Role within the industry?
- Years of Experience?
- Which PBA Manufacturing Test Coverage Method is used across your industry?
- What are the advantages of using this method?
- What are the disadvantages of using this method?
- Do you think Inspection and Electrical Testing should be separated?
- What can be improved on the current method you use?
- Have you used other method? If yes, which one?
- What would you like to see if a new method is introduced?

The survey was administered to Test Engineers, Manufacturing Engineers and Design Engineers of different Original Equipment Manufacturers, Product Suppliers or Test Equipment Suppliers. It was also provided to other individuals involved as well on the design, manufacture and test process of Printed Board Assemblies. The survey was sent to different individuals and individuals of different industries to understand better each persona needs and each industry needs.

Survey results were tabulated and analyzed to understand how they used the methods and generate a new method. This new method used as a starting point the current three methodologies. The end goal was to ensure that as much as defects as possible are covered while optimizing the test and inspection process.

Using the complex index that was introduced into electronics industries and which separate PBA complexity on 3 different categories: Low Complexity, Medium Complexity and High Complexity will be used on the future to test the new method to calculate Printed Assemblies Board Manufacturing Test Coverage. The results will be compared against what is expected from Test Engineers, Manufacturing Engineers and Design Engineers and expressed on the survey.

Results and Discussion

The survey was sent to around fifty Test Engineers, Manufacturing Engineers, Design Engineers and Managers of different Original Equipment Manufacturers, Product Suppliers and Test Equipment Suppliers. Eleven surveys were received, 91% of the participants being Test Engineers and 9% Managers. With regards to the years of experience, 64% of the responders have 10+ years of experience.

From the results obtained the population uses different methods to calculate the Printed Board Assemblies Test Coverage. PPVSF and PCOLA are the methods more used and being identified with 46% and 27% respectively, Several participants used other methods. These other methodologies were not identified by the participants.

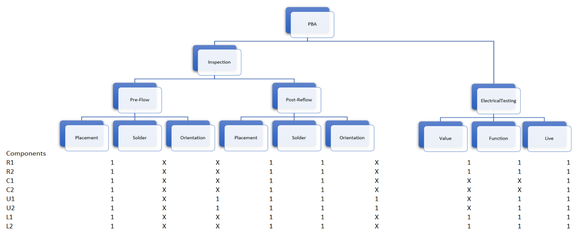
The users of the PPVSF methodology claimed that this is an easy to use method which helps provide a maximum test coverage. Most of the recommendations provided were with regards to the way it calculates weight and how to discriminate inspection versus testing. The advantages that the PCOLA methodology users identified are that is easy to identify manufacturing issues and covers a broad range of different ATE's and factors. Some of the recommendations on improvements for the PCOLA Methodology are to make it more automated and find a way to discriminate between inspection and testing.

When asked about the differentiation of inspection and testing, 73% of the participants answered that it would be good to calculate those separately. Capability of altering coverage analysis manually to reflect current designs, differentiation between inspection and testing, new weight method and standardization were among the answers the participants provided for improvements on existing or on a new methodology.

With the results obtained three requirements for a new methodology can be established. As per the results obtained from the survey some of these requirements should be:

- Shall provide differentiation between inspection and testing
- Shall differentiate also between inspection or processes that cannot be replaced by each other (i.e. inspection before soldering and inspection after soldering)
- Shall be standard across organizations
- Shall include weight depending on complexity of the component

Using these requirements a diagram was created to show how the formula could be designed.



As shown above it breaks down how the Printed Board Assembly components should be catalogued as per the individual processes. There are two major categories: Inspection and Testing. Under inspection there are two sub-categories which are pre-reflow (inspection before soldering) and post-reflow (inspection after soldering). Under these categories then we have the possible defects that can be detected under those processes which are Placement, Solder and Orientation. Under Testing we have then the possible defects that can be detected which are Value, Function and Live. A '1' means a component can be inspected or tested during that process and an 'X' means a component cannot be inspected or tested during that process. The possible defects were an 'X' is shown should not be accounted in the formula as there is no way they can be detected. The formula will normalize the Test Coverage by just taking in consideration the components that can be effectively inspected or tested. The formula for inspection coverage and test coverage would be:

$$\text{Inspection Coverage}_{\text{PSO}} = \frac{Presence_{QTY1} + Solder_{QTY1} + Orientation_{QTY1}}{Presence_{Total-x} + Solder_{Total-x} + Orientation_{Total-x}}$$

$$\text{Test Coverage}_{\text{VFL}} = \frac{Value_{QTY1} + Function_{QTY1} + Live_{QTY1}}{Value_{Total-x} + Function_{Total-x} + Live_{Total-x}}$$

Conclusions

Engineers may have different criteria when doing their jobs, and this is the main reason a standardize methodology to perform their jobs is needed. While more companies go global and start using different companies to assist with the design, manufacturing and testing of their products, having a standard way to calculate Printed Board Assemblies Test Coverage is imperative. A new methodology that is easy to work with and easy to understand by Management and Engineers not involved during the Test Process is essential. Also, having formulas that don't integrate processes may ensure everyone, from engineers to management, understand correctly the information presented, and proper decisions are made when deciding to remove inspection or tests processes due to high cost or due to time constraints. Ultimately, the Test Engineer wants to ensure Maximum Inspection and Test Coverage, along with having an optimum Inspection and Test Flow.

The requirements and new methodology, ICPSO/TCVDF, proposed covers these aspects; however, it needs to be reviewed and approved by the industry to ensure standardization. Also, the industries need to agree on providing a weigh to the components to ensure complex components account for a higher percentage in the formula than components with less level of complexity.

Future Work

Future research may include proving the new methodology, comparing results with already existing methodologies, and discussing the results with industry experts. Also, a committee composed of industry experts should be established. This committee will ensure that there is agreement on the new methodology and that there is standardization on the way the PBA Test Coverage is calculated

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