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Summary of the Doctoral Dissertation:

„Effective Methods for Assessing the Quality of Electronic Module Assembly and Tools Supporting the Repair Process of These Modules”

This dissertation addresses selected issues related to the manufacturing, testing, and repair processes of electronic modules in a production enterprise. The research focuses on four key areas:

a) Examining the impact of selected factors on the thermal properties of RF transistors,
b) Analyzing production-related factors influencing the lifespan of selected electronic modules,
c) Developing tools to support the diagnostics of electronic modules,
d) Designing efficient algorithms for predicting the workload of the repair department in an electronic module manufacturing enterprise.

While the existing literature covers these topics, it often provides only fragmented information. The novel approach of this study includes the application of statistical methods in analyzing the influence of technological process parameters on the thermal characteristics of semiconductor devices and the lifespan of electronic modules, the use of augmented reality in module repair, and the development of mathematical models to describe the repair department's workload.

The main objective of the dissertation is to develop effective methods for assessing the quality of electronic module assembly and to design and test tools that support the repair process of these modules. The quality assessment of soldered joints is based on measurements of the thermal parameters of RF power transistors and the analysis of X-ray images of solder joints. Additionally, the correlation between selected soldering process parameters and the thermal properties of soldered transistors was analyzed.

The dissertation also presents computer tools that assist in diagnosing faults in assembled modules during production, utilizing augmented reality technology. Furthermore, it introduces tools based on statistical methods and artificial intelligence techniques that enable the prediction of the repair department's workload.

The following key theses have been formulated in this study:

1. There is no statistically significant correlation between the size of solder voids in the solder joint under the thermal pad and the thermal parameters of soldered power transistors.
2. It is possible to develop effective methods for diagnosing assembly-related defects in electronic circuits using statistical methods and augmented reality.
3. The use of models based on artificial intelligence methods allows for the effective prediction of the repair department's workload one week in advance.

The study presents research findings on practical aspects of industrial electronic module production. It describes the organization of the industrial assembly process, with a particular focus on prototyping and repairing these modules during production.

Experimental studies and statistical analyses were conducted to illustrate the impact of selected factors characterizing soldering quality on the thermal resistance of transistors in a specific RF system. It was demonstrated that there is no statistical correlation between the size of solder voids and the thermal resistance of RF power transistors. The lifespan of the tested transistors was estimated for different power dissipation levels.

The dissertation also presents research results on the development of an innovative system for diagnosing electronic module faults using augmented reality. This system was developed in collaboration with Cadence at Flex and has been implemented in industrial practice.

Additionally, a predictive algorithm for estimating the workload of the repair department in upcoming weeks was developed and experimentally validated. The algorithm utilizes both a proprietary deterministic model and a machine learning-based model. These tools contribute to improving production yield and reducing material losses.

The presented research results confirm the validity of the formulated theses.