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# Installation of electronic modules in a housing by means of a screw assembly and assessment of the influence of the deformation of the PCB on the installed components

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***Abstract*—Based on the standard for testing in surface mounting, an area of critical deformation is determined when mounting electronic modules in a housing (box). A methodology for testing and determining the deformation has been chosen, as well as tools for conducting experimental measurements. The results of practical measurements of deformations during assembly of electronic modules in a housing are presented. A conclusion is made on the basis of the obtained results with conclusions regarding the admissibility of the process according to the standard.**

***Keywords—assembly, standard, measurement, testing, deformations***

## I. INTRODUCTION

Significant moments in surface mounting is the optimal design for long-term stability during operation. Part of the reasons leading to the defect of the board is related to the appearance of defects during the installation of the board saturated with elements in the housing [1]. A significant contribution to the appearance of defects, a result of the assembly processes, is the appearance of mechanical stress, both in the process of installation and after it, leading to mechanical defects of elements [2].

For all electronic devices it is necessary to install saturated boards in a housing. This installation is done by locking, pressing, riveting and screwing. The screw assembly is the most gentle in terms of mechanical stress and is therefore the most commonly used. The housing and its installation are one of the determining factors for maintaining high reliability during the operation and aging of the product. Such an assembly can also be used for three-dimensional mounting of micromodules on 3D-MID bases.

In any case, the question is to determine the deformations in the specific case and the application of the relevant tests. For this purpose, the standards [3], [4] and a specific measurement scheme are applicable. Depending on the setting [5], a strain gauge type, measurement scheme and impact [6] are selected. If the results are critical, options for additional mechanical hardening by construction and grouting materials [7], [8] or non-standard methods of contact [9] and soldering are sought [10], [11].

A new methodology for measuring and analyzing the deformation and stress of PCBA has been developed using biaxial and triaxial strain gauges placed at critical places of deformation and determining the optimal frequency of data acquisition, which allows analysis of the dynamics of the received stress.

## II. EXPERIMETS

### A. Application of standard procedures

The purpose of this development is validation and maintenance of technological processes in the production of electronic modules, by measuring and analyzing mechanical stress.

Critical from the point of view of deformations are the multilayer ceramic capacitors (MLCCs), BGA and all SMT components, which are one of the most widely used in the manufacture of electronic modules. In order to achieve these high levels of reliability, critical defects due to improper production and assembly of electronic modules must not be allowed. The causes of defects in MLCCs, BGA, SMT are:

- temperature shock;
- excessive bending – fig 1.;
- applied overstresses.

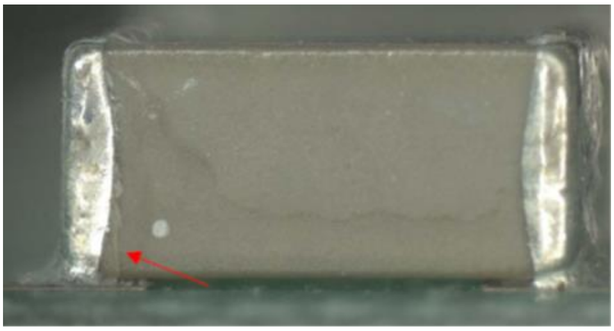


Fig. 1. Damaged capacitor during bending in the body area and in the solder area

The present work is dedicated to the prevention of these consequences and the creation of prevention tools. The paper uses the IPC / JEDEC-9704 standard, which describes the specific guidelines for stress testing of assembled printed circuit boards. The test itself allows to make an objective analysis of the stress levels on SMT components during the assembly process.

### B. Specific solution

In the specific solution a KEMET-MLCC Fex Failure Rate diagram for the allowable stress levels at 1 ppm, 10 ppm, 100 ppm depending on the dimensions of the SMT components is used, shown in fig. 2.

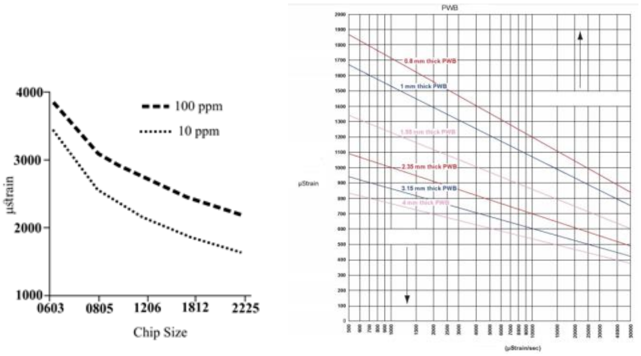


Fig. 2. KEMET-MLCC (Multilayer Ceramic Chip Capacitors) Fex Failure Rate [KEMET inc.] and diagram for determining the maximum stress depending on the thickness of the board [4]

Control of bending of the boards by measuring mechanical stress has proven to be a successful and well-accepted method for detecting and preventing damage in the production processes of the electronics industry. The multifunctionality of the modules determines an increased concentration of components, which in turn leads to an increase in the potential for damage. This requires a large number of PCB manufacturers to produce with certain limits on the stress levels imposed by customers and component suppliers. Mechanical stress measurement technologies use different methodologies, which makes it impossible to compare data and measurement results. The standard covers variations in the placement of sensors, their positioning, the design of the experimental installation, the data collected and the units of measurement. The measurement itself includes the placement of the sensors at the specified locations on the board and the measurement of the deformation in the assembly process. Processes in which stress levels are above certain limits are considered dangerous, and corrective action should be taken immediately. In determining the tolerable levels of stress, the following factors are mainly taken into account:

- Manufacturer's specification stating the allowable stress levels related to the dimensions of the components – fig. 1.
- Permissible levels in accordance with the results of mechanical stress measurements in direct dependence on the stress rate / change in the absolute value of stress per unit time.

The relationship between the stress rate, the absolute value of the stress and the thickness of the board is shown in fig. 2.

When a tensile force is applied to the material, normal stresses σ appear in it, which are related to the applied force - Vishey Beyschlag model.

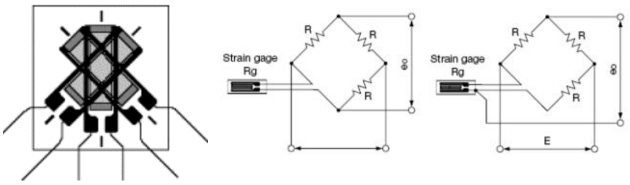


Fig. 3. Strain gauge with its connection scheme in the Wheatstone bridge

The ratio of the elongation to the original length is called the tensile (stress):

$$\boldsymbol{\varepsilon = \Delta L/L} \quad (1)$$

If the applied force is under pressure, then the ratio takes the following form:

$$\boldsymbol{\varepsilon = (-\Delta L)/L} \quad (2)$$

The relationship between stress and tension is expressed through Hooke's law:

$\boldsymbol{\sigma = E.\varepsilon}$, where ε is stress, E is modulus of elasticity, σ is internal stress

The specific resistance of the sensor increases (decreases) when it is subjected to tensile forces (pressure). The ratio of the change in resistivity to the original resistance is equivalent to the product of the voltage with the coefficient expressing the sensitivity of the sensor:

$$\boldsymbol{\Delta R/R = \Delta L/L.Ks = \varepsilon.Ks} \quad (3)$$

For more accurate reading, the Wheatstone bridge shown in fig. 3., through which the changes of the resistances are transformed into changes of the voltages.

Thus the output voltage is proportional to the change in resistance, ie. of the change of the applied forces (stresses):

$$e_0 = \frac{(R_1.\Delta R).R_3 - R_2.R_4}{(R_1 + \Delta R + R_2)(R_3 + R_4)} E = \frac{1}{4}.\frac{\Delta R}{R} E = \frac{1}{4}.Ks.\varepsilon.E \quad (4)$$

When measuring stress, the measuring frequency, bitrate and signal level play a decisive role. All samples must be received and processed simultaneously in order to avoid calculation errors. For correct measurement in the present experiment, the ones shown in fig. 4.:

1. Measurement frequency – 2000 Hz;
2. Desktop screwdriver DEPRAG;
3. Process parameters:
- Screwing power of the desktop screwing - 100Ncm(±10Ncm)
4. Sequence of actions:

Step 1 - Place the thermal paste on the metal lid;
Step 2 - Place the module in the metal cover;
Step 3 - Insert the cover into the socket of the screwing machine;
Step 4 - Screwing the screws.

5. Row for screwing the screws - fig. 4.

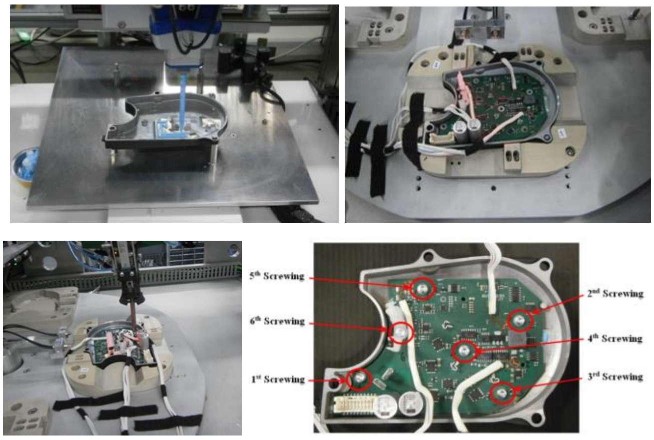


Fig. 4. Experimental staging with a researched module

The location of the surfactants is chosen to be close to the screws and critical components, and their appearance is in accordance with the recommendations for their use. The investigated module with the mounted strain gauges is shown in fig. 5.

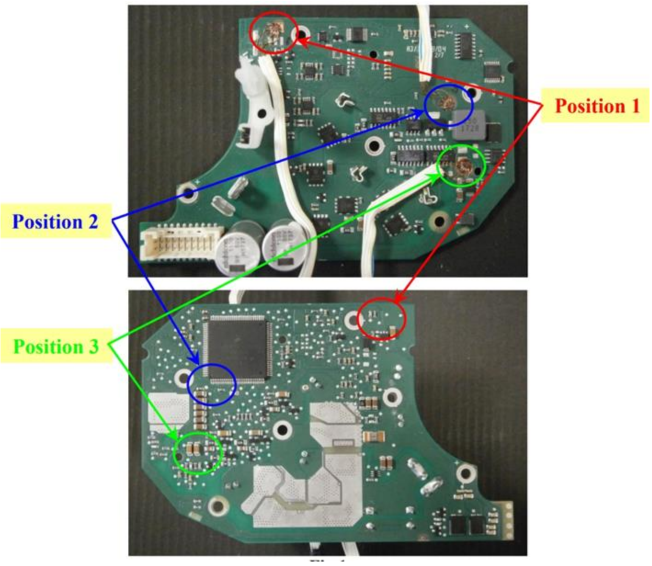


Fig. 5. Experimental panel with located sensors

The strain gauge specification is:

Item 1 KFG-1-120-D17-11L3M3S, Triaxial, 119.6 Ω, scale gauge factor:

- Channel 1 - 2.06
- Channel 2 - 2.06
- Channel 3 - 2.06

Item 2 KFG-1-120-D16-11L3M3S, Biaxial, 119.6Ω , scale gauge factor:

- Channel 4 – 2.06
- Channel 5 – 2.06

Item 3 KFG-1-120-D17-11L3M3S, Triaxial, 119.6 Ω, scale gauge factor:

- Channel 6 - 2.06
- Channel 7 - 2.06
- Channel 8 - 2.06

In the present experiment, the intelligent measuring system shown in fig. 6 with the following specification:

1. Measuring interfaces KYOWA PCD 300A - 4 channels - 2 pieces;

2. HP Pavilion G6 PC/Intel Core i7 – 3.1GHz, 8Gb RAM/;

3. Measurement software - PCD 30A;

4. Analysis software DAS 100.

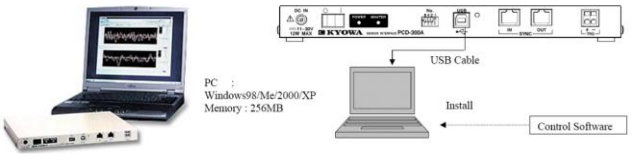


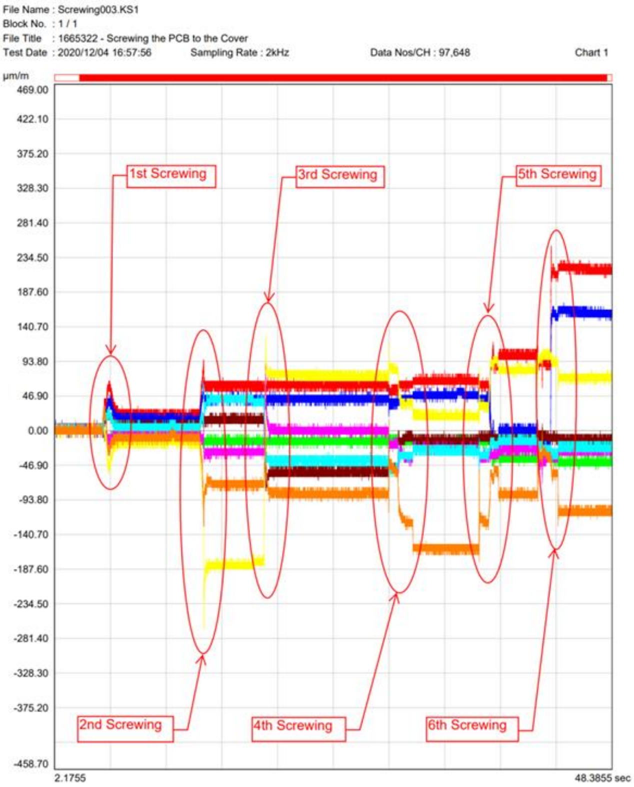
Fig. 6. KYOWA intelligent measuring system

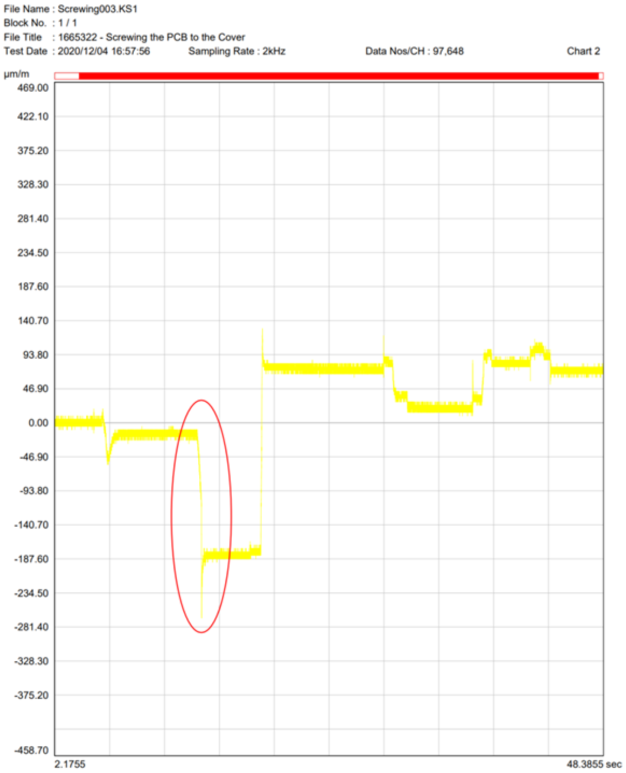
For the specific experiment, PCB type FR 4 TG⩾150 C, 1.6 mm multilayer, with mounted components of size 0603 and mounting in an aluminum box with thermal paste application were used.

## III. RESULTS

### A. *Measurement results*

In fig. 7. the obtained results from the measurement are shown.





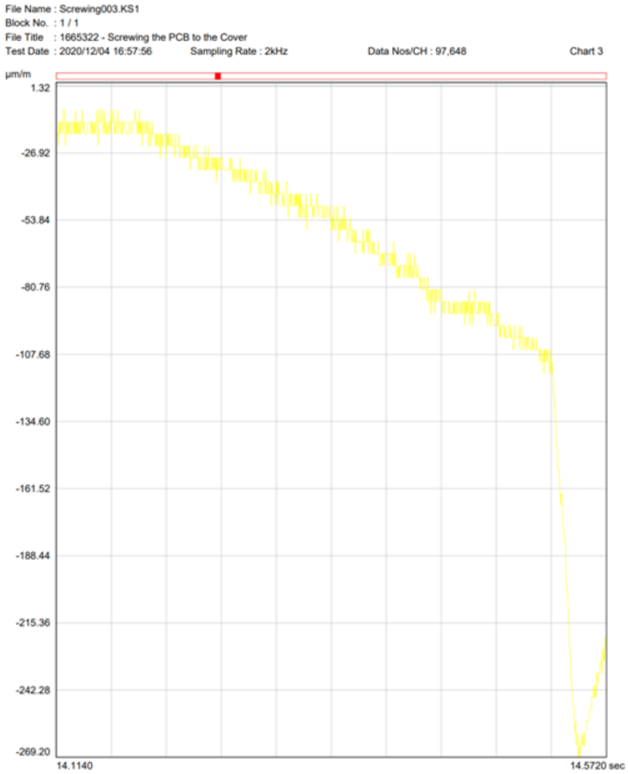


Fig. 7. Measurement results

The maximum deformation value is 269.2 με and is measured on channel 6 for screw 2, according to fig. 7 Chart 1. In fig. 7. Chart 1 clearly records the deformation and stress when turning each screw. The process of turning all the screws takes 55 seconds. In fig. 7 Chart 2 has a stress background of 20 με and an amplitude of 250 με.

### *B. Analysis*

For components 0603 and requirements for 100 ppm defect, the stress rate is 4000 με / s according to the requirements of fig. 2., the first diagram. Since the thickness of the PCB is 1.6 mm, according to fig. 2, the second diagram, the maximum deformation should not exceed 1000 με. During the measurement, a maximum value of 269.2 με was recorded for all monitored points. Therefore, the deformations at the critical points in the periphery of the single board do not exceed the allowable ones. The many times lower value allows for future additional optimization of the availability of both elements within the board and at the locations of the screw assembly.

## IV. CONCLUSION

The requirements and methods for determining the stress in printed circuit boards in the process of manufacturing electronic modules are applied. Variants for determining the points for controlling the deformation, fixing the sensors and measuring at a specific board topology are presented. The results are for the assembled end product process.

An increasing number of customers require PCB manufacturers to produce with certain limits for stress levels. Thus, they guarantee minimization of the risk of such defects and reliable operation of the manufactured electronic modules. Determining these limits is often based on experience and is the result of long-term measurements and comparisons of results.

The measurement of mechanical stress allows for an objective analysis of the stress and stress level to which all SMT components are subjected, during assembly, testing, depanelization and other production processes. The sensors and methods used can be oriented differently, including for 3D configurations.

After many measurements and analysis of the results, we can assume that the described method is a necessary tool for prevention, as well as a method for locating and proving sources of mechanical stress.

## ACKNOWLEDGMENT

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