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IMPROVEMENT OF CIRCUIT BOARDS TESTING SET CALIBRATION

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Abstract: *All the time is need that a product for market shall have assured liability of work during its lifetime and especially this is case for electronic device where competitive ability of the product is minimum requirement taking into account low-price production from developing countries. A circuit board is one of the main parts in an electronic device.*

Test set for the circuit boards are used as calibre to assure proper work of the boards. Test set has pins that will catch the fringe area of the circuit board test pad and therefore must have as high as possible accuracy of measures as needed. Calibration of test set gives confidence that parameters are on the required level.

One way to improve calibration is take into account more precisely influence of measurement uncertainty.

Using uncertainty data allows finding ways to minimise the values of influence components depending on concrete conditions during calibration procedure.

The main task of this work was help to have the test set with higher accuracy parameters, but with the same price level as before.

Key words: calibration, measurement uncertainty, circuit board

1. INTRODUCTION

Now-a-days requirement is that a electronic device shall have high quality and assured liability of work during its lifetime. Needed is competitive ability of the product taking into account low-price production from developing countries. A circuit board is one of the main parts in an electronic device.

Test set for the circuit boards inspection is used as calibre to give assured work of the boards. Test set has pins that will catch the fringe area of the circuit board test pad and therefore must have as high as possible accuracy of measures as needed. If contact were not obtained, the result would be a false transmitted signal or absence of it.

Test set parameters are inspected and justified through calibration. Optimized calibration of test set allows to achieve a better quality of the end product without leading to a higher price. One way to improve calibration is to take into account more precisely influence of measurement uncertainty. This allows estimate the tolerances of test set more adequately and with higher accuracy. Using uncertainty data allows finding ways to minimise the values of influence components depending on concrete conditions of calibration.

The main task of this work was to have the test set with higher accuracy parameters, but with the same price level as before. This study gives theoretical bases for the uncertainty estimation for the calibration process of circuit boards test set and presents a model for estimation of uncertainty which takes into account specific corrections from the influence factors. Evaluation allows identifying and reducing the influence of the factors that affect the uncertainties [1] of components. Work presents estimated values of uncertainties for influence factors. Presented concrete model and values are innovative in this field and allows achieve a better quality of the test set of circuit board without leading to a higher price.

2. CALIBRATION OF CIRCUIT BOARDS TEST SET

2.1 Elementary testing module

Testing is used to control the compliance of circuit boards with requirements. The main task of testing is to carry out control of the test points on a circuit board. The most important equipment used for testing is a test set with pins and control sticks (Fig. 1). The dimensional measures of the test set must be as accurate as possible. On the other hand, the test set must be uncomplicated and rigid enough to allow its permanent use in the difficult conditions where a significant number of tests were carried out during each working day.

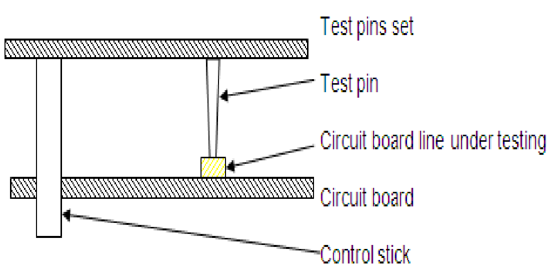

Fig. 1. Elementary test set for testing of circuit boards

An elementary test set consists of a board with test pins and control sticks [2]. The pins are connected to board with electrical contacts and have measures suitable for the control of test points of circuit board. During control operation, the sharp end of test pin will have electrical contact with the control point of circuit boards.

The task of control sticks is to place the test set properly against the circuit board and have high accuracy of fitting the stick into the hole in the circuit board. The most important dimension, which has importance during testing, is the distance between the centre of test pin centre and the centre of control stick. Its value is estimated and taken into account during the design of circuit board.

The test set has to be rigid enough to allow permanent use in difficult conditions. The accuracy and conformity with design of the test set is essential for the quality of testing. The test set is calibrated against the calibration set.

1.2 Main parameters of calibration procedure

The designer gives values for the tolerances of circuit boards measures. Test set parameters shall be estimated taking into account those. By calibration shall be controlled essential measures and its deviations. Main parameters of a simple test set which are needed to control are given on Fig. 2.

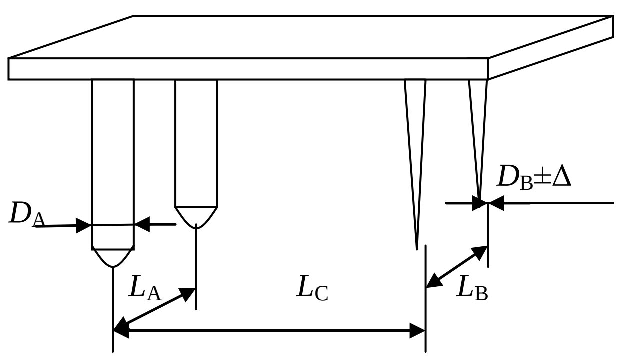

Fig. 2. Simple test set calibration parameters

Important parameters for calibration are: dimensional measures of length L_i and diameters D_i; dimensional measures deviations Δ_i, geometrical deviations parallelism and perpendicularity of sticks and rods and electrical contact of sticks. Sometimes is more better control angles.

1.3 Main influence factors during calibration procedure

Calibration of the test set is influenced with various factors which shall be taken into account. Analysing factors influence can be found ways to improve whole calibration procedure [3].

Main components groups having importance for uncertainty estimation by test set calibration are listed as follows:

- test set calibre: calibre design; geometrical and measures tolerances (GPS) of calibre; environment; material; manufacturing, calibration method of calibre;
- calibration method: replacement tolerances during calibration, calibre and measuring instrument locating tolerances, test set holder tolerances;
- test set: test set dimensional parameters; environment and its variation during the calibration of test set; test set specificity and its behaviour during test; test set sensitivity and stability (reproducibility/repeatability), manufacturing specificity of a test set:
- environment: humidity, temperature, vibrations, noise, altitude, interference fields, barometric pressure, pureness;
- human factor, operator: sensitivity, competence, experience, commitment.

The factors that influence calibration are shown in Fig. 3 as a summary structural scheme, this is fundamental for the further uncertainty estimation.

3. UNCERTAINTY COMPONENTS OF CALIBRATION PROCEDURE

Parameters presented in Fig. 3 give components, which have influence to the uncertainty budget of calibration of test set. The effect of some of these components may be little as long as they remain constant, but could affect measurement results when they start changing. For example, the rate of temperature change can be particularly important.

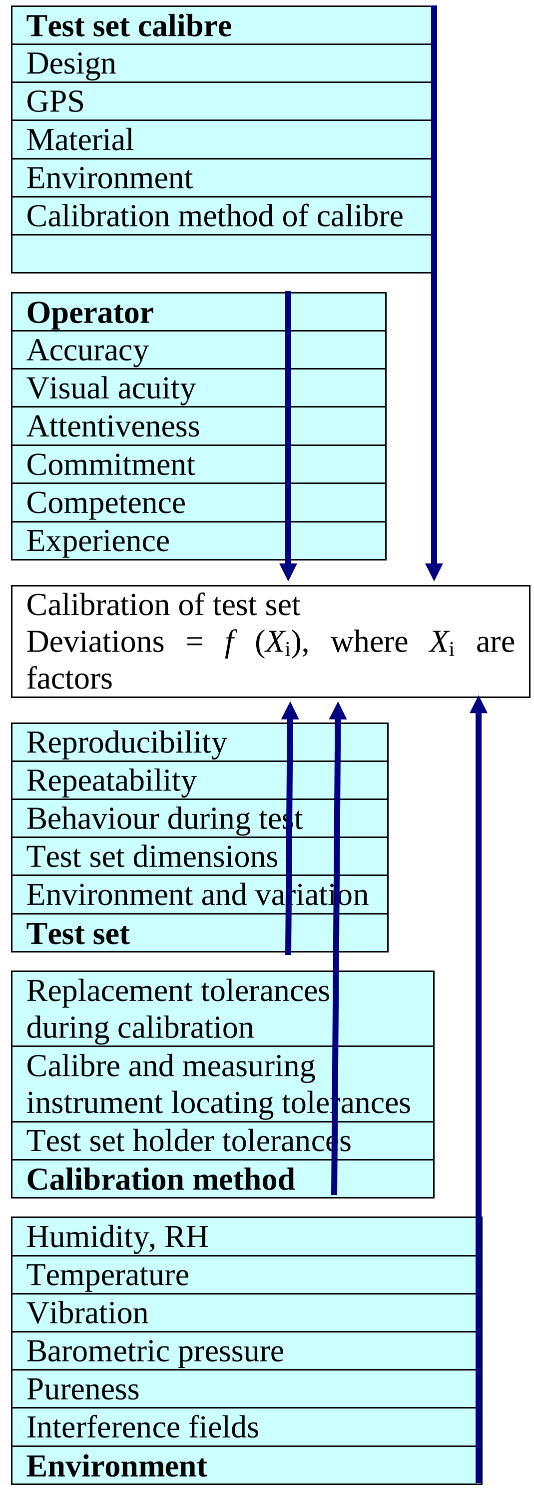

Fig. 3. The general model of the factors influencing the calibration of the test set

Combined uncertainty u_C is found through the estimation of standard uncertainties caused by individual factors X_i. Combined uncertainty u_B is calculated by equation:

$$u_C = \sqrt{u_{TC}^2 + u_{HF}^2 + u_{TB}^2 + u_{CB}^2 + u_{EC}^2} \qquad (1)$$

In the equation (1) are given the main grouped factors, where u_{TC} is uncertainty from the test calibre (calibration instrument), u_{HF} is uncertainty from operator = human factor; u_{TB} is uncertainty from the test set, u_{CB} is uncertainty from the calibration process (from method), u_{EC} is uncertainty from the environment conditions. Each uncertainty component has a concrete sensitivity coefficient. In equation (1) sensitivity coefficients are 1, i.e. uncertainty components are estimated on the same influence level.

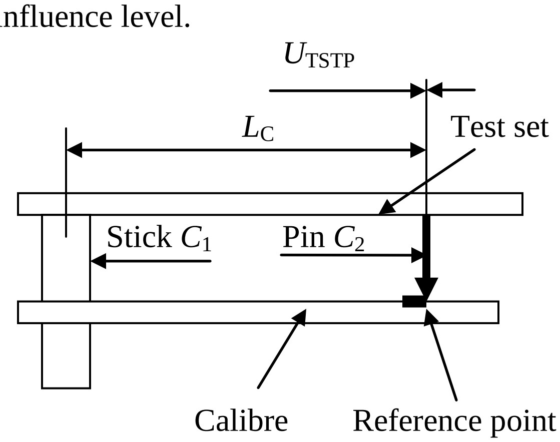

Fig. 4. Uncertainty components scheme by calibration of test set; u_{TSTP} – uncertainty of test set test point

In Fig. 4 are shown uncertainty components caused by influence factors during calibration procedure for simple test set. Uncertainty components are shown in places where they have main effect.

Further is an example of uncertainty components values for one measure of test set. Summarised values, without taking into account the human factors u_{HF}, of components are given in Table 1. Values are estimations collected during long years of experience and measurements in the production company. Denoted measure is on a line from the centre of stick C_1 up to the centre of pin C_2 (measure L_C) with a nominal value of 150 mm (see Fig. 4).

Expanded uncertainty U must be found using the coverage factor k = 2, which gives the probability level of ca 95 % for estimated uncertainty. So calibration of test set nominal length 150 mm can have expanded uncertainty 0,14 mm (relative value 0,11 %).

Parameter	Distri-bution	Standard uncertainty
Influence of calibre, u_{TC}	Trian-gular	15 % from u_C
Influence of test set, u_{TB}	Trian-gular	20 % from u_C
Influence of calibration methods (process), u_{CB}	Trian-gular	10 % from u_C
Environmental influence, u_{EC}	Trian-gular	50 % from u_C
Combined uncertainty of calibration, u_C		0,07 mm
Expended uncertainty: $U_C = k \cdot u_C$, probability level ca 95 %		0,14 mm

Table 1. Combined uncertainty of test set calibration

4. POSSIBILITIES TO MINIMIZE VALUES OF COMPONENTS

Uncertainty estimation allows optimisation of influence factors. Use of uncertainty of components and data given in Table 1 allows find ways to minimise the values of influence components depending on concrete conditions of calibration. Visible results can be achieved by the elimination of accumulative tolerances of the test system, which are included in u_{TB} in

Equation (1). The problem of self-location has received considerable attention by robotics and some techniques [4] from there can be used for elimination of above deviation.

5. CONCLUSIONS

Parameter tolerances of the test set for testing of circuit boards can be corrected, taking into account more precisely the uncertainties from influence factors.

Minimising the effect of influence factors by analysis, dependent link tolerance for test set can be reduced up to (15 – 20)% without raising the costs of calibration.

Minimising the effect of only one influence factor from the environmental temperature, through controlling it more carefully, can give good results.

6. REFERENCES

1. Raba, K. *Uncertainty Focused Product Improvement Models*. Tallinn University of Technology Press, Tallinn, 2009.
2. Raba, K., Kulderknup, E. 2008 Mobile phones control set dimensional chain calculation involving measurement uncertainty. *6th International Conference of DAAAM Baltic, Conf. Proc.* DAAAM International Vienna, Tallinn, 129-134.
3. Wang, C. M., Iyer, H. K. Propagation of uncertainties in measurements using generalized inference. *Metrologia*, 2005, **42**, 145-153.
4. Kolláth, L., Halaj, M., Kureková, E. Positioning accuracy of non-conventional production machines. *Proc. of XIX IMEKO World Congress.* IMEKO, Lisbon, 2009, 2099-2102.

7. ACKNOWLEDGMENTS

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