Improved Impedance Measurement Precision Utilizing Innovative Test Fixture Design

J. Gaylord Gasque
SKG Automation LLC
974 Miramar Drive
Vista, CA 92081
Phone: (760)533-1019
gaylordgasque@skgautomation.com

William R. Harrell, Kyle Jenko
Clemson University
Holcombe Dept. of Electrical and Computer Engineering
205 Riggs Hall, Box 340915
Clemson, SC 29634-0915
Phone: (864)656-5918
wharrell@Clemson.edu

Kyle Jenko (Current Affiliation)
Universal Avionics
4500 River Green Pkwy, Duluth, GA 30096
jenko0124@gmail.com

Introduction to Test Tweezers T.T.

+ Test tweezers are mechanically similar to hair removal tweezers, but test contacts and signal cables are added to enable electrical testing.
+ Applications include production testing of two terminal passive components – capacitors, inductors, and resistors, for example.
+ Traditional test tweezers are widely used for production testing of commercial capacitors.
+ Traditional test tweezers are not used much for applications that require precision testing, such as QC testing, lot qualification, testing low-value, tight-tolerance NPO capacitors, and selecting golden chips for correlating high-speed testers.

Characteristics of Traditional Test Tweezers

- Traditional tweezers use flexible legs to enable the tweezing function.
- Small alignment errors occur in the X and Z axes as tweezing is initiated.
- These alignment errors result in measurement errors that are random and not controlled, so the open compensation routine built into the meter cannot compensate properly for them.

Traditional Test Tweezers {Continued}

- Relatively large area electrodes used in the test contacts result in larger uncontrolled stray capacitance, which results in reduced precision.
- Some sort of gauge block is required to perform the open compensation routine.
- Variations in the location of the gauge block, the operator’s strength, hand size, and method of holding the test tweezers result in further reduced precision as well as repeatability.

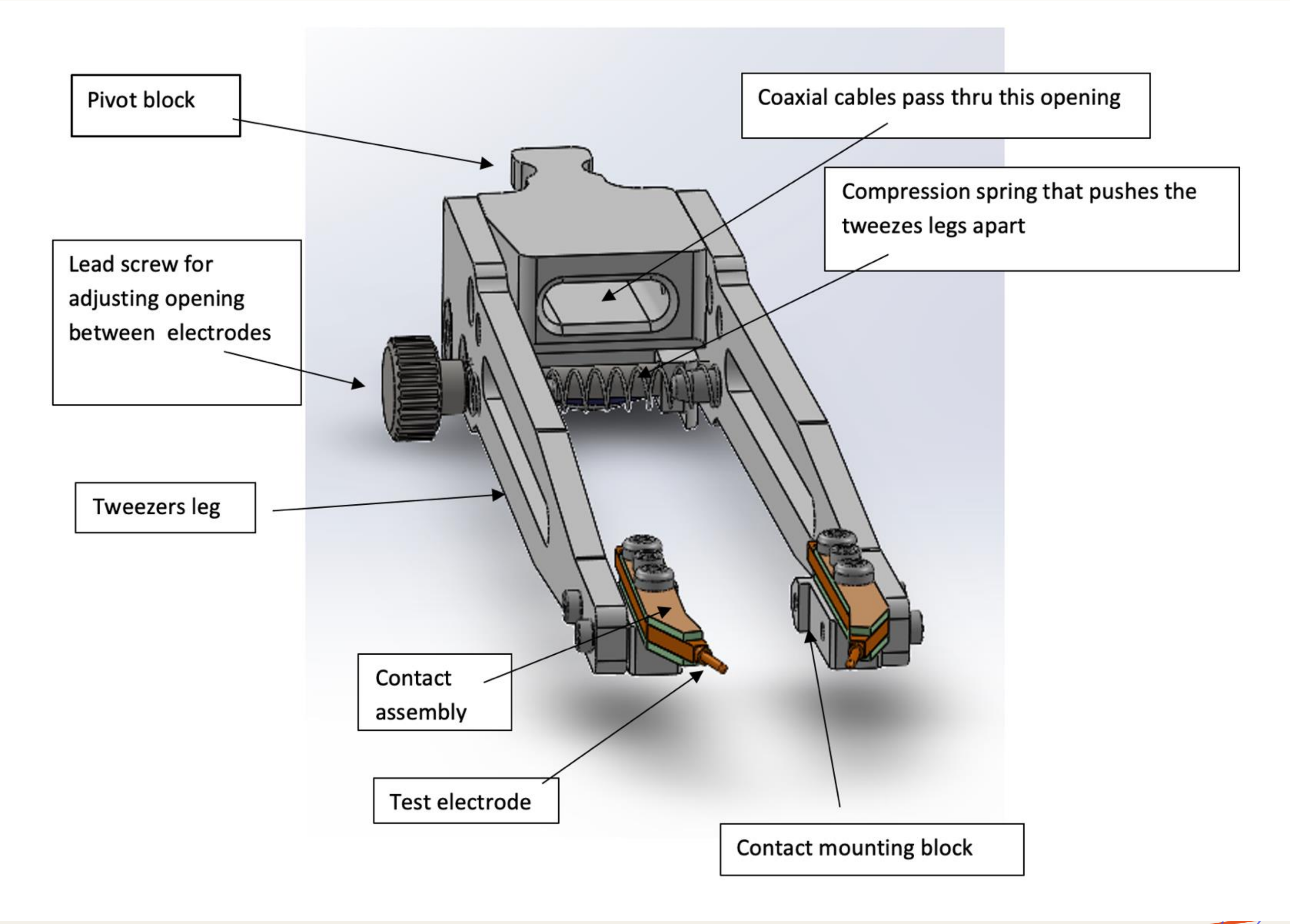
Goal of this Work

- Develop new tweezers paradigm with more refined mechanical design.
- Decoupling the fixture mechanical function from the fixture electrical function.
- Improved measurement precision and repeatability.
- Decreased dependence on individual operators.
- Enhance TT applications to include testing low value, tight tolerance MLCC’s, lot qualification, and measuring “golden chips” that are used for correlation of high-speed automatic testers.

New Tweezers Design
Illustrated in Figure 1

- Improved test precision is achieved by separating or decoupling the fixture electrical function from the mechanical function
- The tweezers legs are rigid, eliminating all issues related to flexible legs, including operator hand size, hand strength, and hand position.
- The lead screw eliminates the need for a gauge block.
- Furthermore, the lead screw enables the operator to set the distance between electrodes to the exact length of the MLCC, further improving open compensation results.

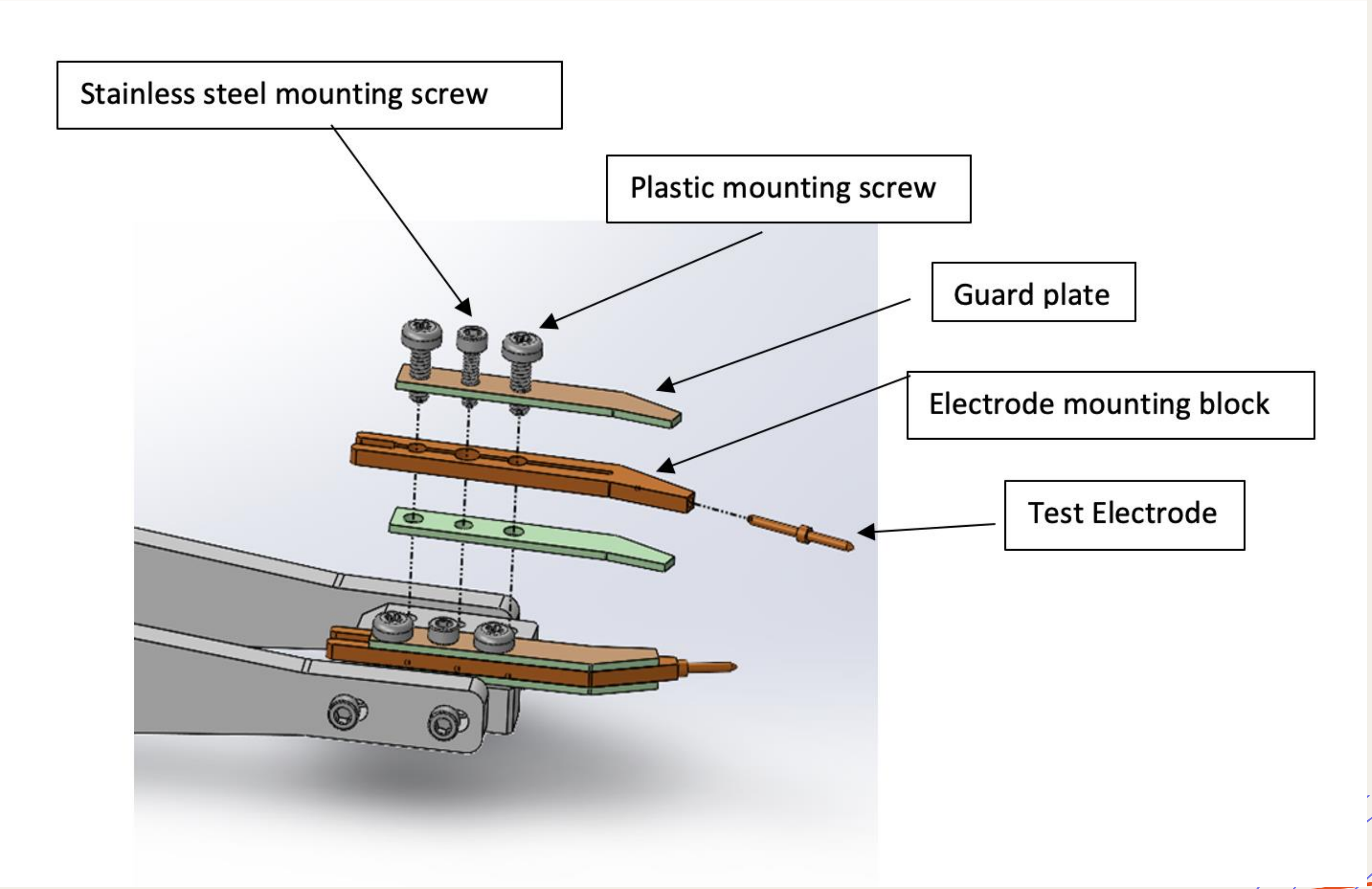
Figure 1: Overall view of test fixture



New Tweezers Design
Illustrated in Figure 2

- The design of the test contact ensures a rigid assembly, eliminating test errors related to contact flexing.
- The electrode mounting block design ensures that a four terminal test circuit is maintained to the test electrode.
- Guard plates shield the test contact from outside influences, helping to maintain test integrity.

Figure 2: Exploded view of contrast assembly



Experimental Design

1. Testing low value, tight tolerance MLCC chips is the target application for the tweezers, motivating the Experimental Design.
2. Goal – simulate, as closely as possible, the testing environment in a MLCC factory
3. Tested NPO chips - 1nF, 100pF, 10pF, 1pF, and 0.1pF
4. Tested each chip 10 times while performing an open and short compensation between each test
5. Testing also designed to confirm de-coupling between the electrical and mechanical functions of the test fixture

Experimental Design {Continued}

6. Focused on worst-case scenario, which is the maximum and minimum values in the series of 10 tests, and specifying the difference as the test process capability
7. Goal was to demonstrate a test capability of at least 10x the stated tolerance
8. The operator was a fourth-year engineering department undergraduate student
9. The student had never used or seen test tweezers before
10. His training consisted of about 15 minutes of instruction and an hour of practice

Experimental Results

- The primary test parameter is ΔC – The Difference in the Maximum and Minimum of the Ten measured Capacitance values for each device
- Results:
- For C_p = **0.5pF, ΔC = 0.0104pF** – Typical Tolerance = + /- 0.1pF
- For C_p = **1.0pF, ΔC = 0.0067pF** – Typical Tolerance = + /- 1%
- For C_p = **10pF, ΔC = 0.0112pF** – Typical Tolerance = + /- 1%
- For C_p = **100pF, ΔC = 0.0087pF** – Typical Tolerance = + /- 1%
- For C_p = **1.0nF, ΔC = 0.015 pF** – Typical Tolerance = + /- 1%

Summary & Conclusions

- New Test Tweezers design presented, which decouples the fixture mechanical and electrical functions
- Demonstrated a process precision, for all capacitance values, that is at least 10 times greater than the manufacturers' specified tolerance
- For all capacitors tested: $\underline{\Delta C < 0.02pF}$
- Operator was minimally experienced, and performed open and short compensation between each of ten measurements for each capacitor
- Repeatability is significantly improved

Summary & Conclusions {Continued}

- These results qualify the test tweezers presented in this paper for the most demanding testing functions in an MLCC factory
- Benefits of the improved precision potentially include:
  - Tighter guard bands,
  - Improved yields
  - Reduced scrap
- Capability to test MLCC's in the size range 1005 to 4440, facilitates reduction of the number of different test fixtures that must be acquired and maintained
- Operator training requirements are similarly reduced