# INTELLIGENT TEST BRIDGE DESIGN FOR SUSTAINABLE YIELD IMPROVEMENT IN AIR CAVITY CERAMIC BURN-IN TESTING

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## ABSTRACT

In high-volume semiconductor manufacturing, process reliability and cost-efficiency are essential. At Ampleon Philippines, the transfer of a Burn-In Test process for the ACC package type from Ampleon Nijmegen led to a significant yield drop of 66%, caused by cracked ceramic caps. This paper presents a mechanical design solution, a "Test Bridge" to improve planar force distribution during testing. The approach included root cause analysis, design prototyping, validation analysis and production trials. Results showed a complete elimination of cracked caps and 8% increase in units per hour (UPH), with no negative electrical impact. This study demonstrates how mechanical innovation can enhance process stability, product reliability, and production efficiency.

## 1.0 INTRODUCTION

The Burn-In Test procedure is essential for the DeviceA series under the ACC package type, which exhibits significant Idq drift during operation in the Digital Video Broadcast Test (DVBT), potentially leading to failures in meeting linearity specifications. This drift is attributed to early-life degradation mechanisms inherent to the 8HV process and the associated die design. Burn-In Test serves to precondition the devices by accelerating these degradation effects in a controlled environment by applying a DC voltage of 97V at 25°C for 3.5 hours, thereby stabilizing Idq behavior before the devices are deployed in actual application. This ensures improved electrical stability and reliability during field operation.

While Ampleon Nijmegen has conducted Burn-In Testing for DeviceA series without encountering any cracked ceramic caps, the initial production run at Ampleon Philippines resulted in a significant yield drop to **66.17%**, as illustrated in Figure 1.

| Batch | QtyIn | QtyOut | #BLT Reject | %Reject |
|---|---|---|---|---|
| PQ2307001100 | 60 | 22 | 38 | 63.33% |
| PQ2307001000 | 40 | 32 | 8 | 20.00% |
| PQ2307000800 | 40 | 33 | 7 | 17.50% |
| PQ2307001300 | 60 | 47 | 13 | 21.67% |
| PQ2307001700 | 20 | 19 | 1 | 5.00% |
| PQ2307001200 | 60 | 57 | 3 | 5.00% |
| PQ2307000700 | 20 | 12 | 8 | 40.00% |
| PQ2307001400 | 60 | 18 | 42 | 70.00% |
| PQ2307000900 | 20 | 16 | 4 | 20.00% |
| PQ2307001900 | 14 | 6 | 8 | 57.14% |
| PQ2307001800 | 18 | 13 | 5 | 27.78% |
| PQ2307001600 | 46 | 25 | 21 | 45.65% |
| PQ2307001500 | 12 | 11 | 1 | 8.33% |
| **Total** | **470** | **311** | **159** | **33.83%** |
| **Yield** | **66.17%** | | | |

Figure 1. Initial Yield of Production Run of DeviceA series

The units with cracked caps having leakage on top of the caps. some of which were not visible to the naked eye but were confirmed through Bubble Leak Test (BLT) as shown in Figure 2.


Figure 2. Defect Signature with Leakage on Top

A key hypothesis emerged: the manual nature of the Burn-In process may introduce inconsistent force applied across different operators and shifts. While the standard procedure in both sites involves placing the contact blocker on top of the unit and initially tightening it by hand before using an electric screwdriver as shown in Figure 3, operator variability in force applied and sequence may lead to uneven pressure distribution. This was especially relevant at Ampleon Philippines, where Burn-In operates continuously across multiple shifts and operators, compared to Ampleon Nijmegen, which runs the process with only one trained operator.

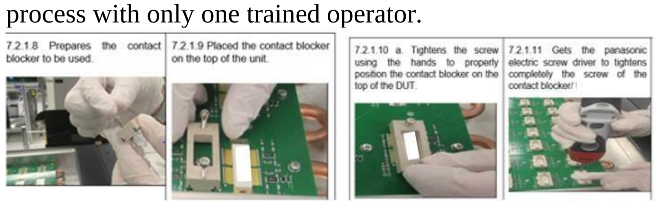



Figure 3. Work Instruction of Burn-in Test for Operator Reference

| Aspect | Controlled (e.g., Single Operator, Consistent Torque) | Uncontrolled (e.g., Multiple Operators, Manual Torque) |
|---|---|---|
| Torque Consistency | High | Low |
| Pressure Distribution | Even | Uneven |
| Risk of Over-tightening | Low | High (risk of "nutcracker effect") |
| Process Repeatability | High | Low |
| Risk of Damage (Cracks) | Minimal | Significant |

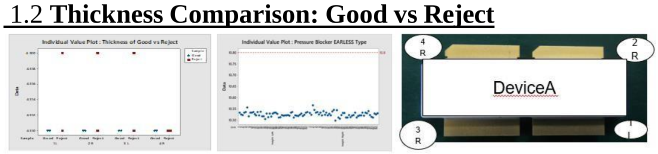
The "nutcracker effect" arises when screws are unevenly tightened, particularly if one side is secured too tightly before the other leading to concentrated force directly on the fragile ceramic caps. The current contact blocker design channels force straight to the ceramic caps and DUT source area, increasing the risk of cracks, especially when planar force is not maintained.

The containment action involved performing 100% BLT after Burn-In, and several potential contributing factors were investigated:

### 1.1 Visual check: Good vs Reject


Result: *With sufficient glue. Passed in Visual Criteria*

### 1.2 Thickness Comparison: Good vs Reject




Result: *Not significant*

### 1.3 POD vs Pressure Block Diagram

| Actual Measurement of Affected Sample | | POD specs 4.2 - 5.1mm | |
|---|---|---|---|
| Measurement | mm | Measurement | mm |
| Actual measurement of sample | 11.31 | Actual measurement (A+ Actual sample) | 11.31 |
| Pressure blocker height © in BD | 10.8 | Total Height in BD | 10.8 |

Result: *Not significant*

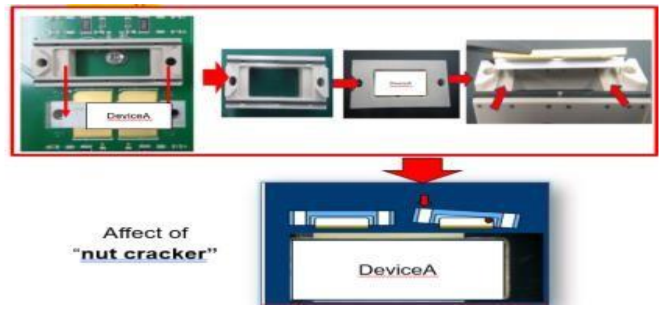
### 1.4 Validation of Way of Working

DeviceA
No. of Samples: 4pcs
Pressure Contact Blocker: SOTB (dedicated)
BLT is perform before and after every step
Loading time used : 5mins

| Item | BLT | Cracked Caps | Cracked Glue | Validation |
|---|---|---|---|---|
| 1. Correct mounting of unit to loadboard as per WI | Passed | None | None | |
| 2. Correct tighten of screw as per WI but using incorrect pressure blocker SOTA | Passed | None | None | |
| 3. Incorrect tighten of screw (tighten first the right side then followed by the left side ) + correct pressure blocker | Passed | None | With Cracked Glue (1 pc out of 4pcs) | With Cracked Glue (1 pc out of 4pcs) |

Result: *Showed cracked glue on the gate side, but not matching the signature of cracked caps.*

### 1.5 Design of Contact Blocker




Result: *Confirmed that the design allows direct force application to the ceramic caps with limited control over pressure uniformity.*

In-house improvised tooling solutions failed to fully address the issue, reaffirming the need for a design-based solution to regulate force application during Burn-In.

This paper aims to identify and eliminate the root cause of yield loss due to cracked caps during the Burn-In Test by introducing a mechanical design intervention - the Test Bridge. The proposed design seeks to improve planar force distribution, mitigate operator-induced variability, and ensure reliable, damage-free testing in a high-volume production environment, thereby supporting consistent production yield and process stability.

## 2. 0 REVIEW OF RELATED WORK

The fragility and complexity of modern electronic components have made mechanical stress management an increasingly important emphasis in semiconductor testing. Several studies have shown the need to manage mechanical forces in ensuring device integrity and long-term reliability. A.J. [1] *stressed the need to use uniform pressure during mechanical stress tests to avoid the production of microcracks in ceramic-based packages, which are particularly vulnerable to stress-induced failures*. This finding emphasized the critical importance of consistent pressure to prevent microcracks in ceramic-based packages—a failure mode directly observed in the ACC devices thus need to design-driven solution. *Caraig [2] investigated the significance of planar force distribution in mechanical assembly design, revealing uneven loading as a typical cause of component misalignment and damage during test and handling activities.* These foundational insights are directly relevant to the ACC package, where the observed "nutcracker effect" illustrated the risks of uncontrolled force application. Building on these concepts, the current study applies mechanical design principles in a high-volume production setting by developing a customized "Test Bridge" prototype. This solution regulates force application by evenly distributing clamping pressure during DUT engagement, reducing localized stress on the fragile ceramic caps and enhancing structural reliability as shown in Figure 4.0. Rather than focusing on theoretical stress analysis, this work presents and validates a customized test bridge mechanism in a production scenario using both real- time deployment and prototyping. By combining empirical testing and mechanical design considerations, the methodology tackles a persistent yield loss problem that was noticed during the Burn-In Test procedure. The findings show how focused mechanical interventions can improve production efficiency and product quality in high-volume semiconductor testing operations by demonstrating measurable gains in test stability and device reliability.

## 3.0 METHODOLOGY

In collaboration with the mechanical design team, a prototype was developed featuring an improved pressing mechanism for the Device Under Test (DUT) during the Burn-In Test process. The Test Bridge design ensured that the applied force was more planar and evenly distributed, avoiding direct pressure on the ceramic caps, which are prone to micro-cracking under concentrated stress. See figure 4.

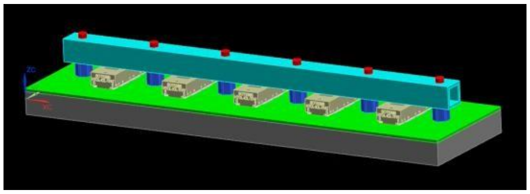


Figure 4. Test Bridge Prototype Design

As part of the qualification process, a torque assessment was conducted to evaluate the repeatability of the clamping force applied on Device Under Test (DUT) engagement in the Burn-In Test. This was done by using a calibrated electric screwdriver with different brands applying various torque settings during the fastening process.

Two electric screwdriver brands, Panasonic and Bosch, were tested across five torque settings ranging from 1 to 5 Nm. For each setting, 40 samples were evaluated, resulting in a total of 200 samples per brand. The primary criterion assessed was the presence of cracked caps because of over-tightening or inconsistent force applied.

The results showed zero reject quantity across all torque settings for both Panasonic and Bosch screwdrivers. Additionally, no cracked caps were observed in any of the 400 samples tested. These findings indicate that the applied torque settings, across both brands, do not contribute to cracked caps and have no adverse impact on DUT integrity throughout the evaluated torque range.

Based on these results, both Panasonic and Bosch electric screwdrivers are deemed qualified for use in the Burn-In Test fastening process, with torque settings from 1 to 5 Nm considered safe and reliable, as shown in Figure 5.

| Electric Screwdriver Brand | Tourque Setting (Nm) | No. of samples | Reject Qty wrt Crack Caps | Remarks |
|---|---|---|---|---|
| Panasonic | 1 | 40 | 0 | No crack caps observed |
| | 2 | 40 | 0 | No crack caps observed |
| | 3 | 40 | 0 | No crack caps observed |
| | 4 | 40 | 0 | No crack caps observed |
| | 5 | 40 | 0 | No crack caps observed |

| Electric Screwdriver Brand | Tourque Setting (Nm) | No. of samples | Reject Qty wrt Crack Caps | Remarks |
|---|---|---|---|---|
| Bosch | 1 | 40 | 0 | No crack caps observed |
| | 2 | 40 | 0 | No crack caps observed |
| | 3 | 40 | 0 | No crack caps observed |
| | 4 | 40 | 0 | No crack caps observed |
| | 5 | 40 | 0 | No crack caps observed |

Figure 5. Torque assessment result

A Change Failure Mode and Effect Analysis (CFMEA) was conducted to assess potential risks associated with design modification. The evaluation indicated a low-risk level, and the only required action was to update all documentation and standard operating procedures related to the implementation.

| PROCESS/STATION : | PFMEA OF RF POWER BURN-IN TEST | | |
|---|---|---|---|
| 7.0 Loading of Device Under Test | 7.1 | Correct orientation of DUT on the loadboard | Low Risk |
| | 7.2 | Correct tighten of screws | Low Risk |
| | 7.3 | Loading of units in serialize | Low Risk |
| | 7.4 | Check if the top cover is locked | Low Risk |
| | 7.5 | For devicesA, check if uses correct tool. Test bridge + contact blocker | Low Risk |

Prior to full deployment, the new Test Bridge underwent functional validation through prototyping and production trials. Following successful results, the design was presented to and approved by the Ampleon Global Change Control Board (GCCB), allowing for complete rollout across production lines.

## 4.0 RESULTS AND DISCUSSION

The first production run utilizing the Test Bridge demonstrated clear improvements in both mechanical reliability and operational efficiency.

As shown in **Figure 6**, the occurrence of cracked ceramic caps was eliminated following the implementation of the Test Bridge in ACC package Burn-In Tests. This confirmed its effectiveness in addressing the previously identified failure mode.

| Lot No. | Burn-In Qty In | Burn-In Qty Out | Burn-In Yield | Reject Qty wrt Crack Caps |
|---|---|---|---|---|
| PQ2307002200 | 60 | 60 | 100.00% | 0 |
| PQ2307002200 | 60 | 60 | 100.00% | 0 |
| PQ2307002200 | 60 | 60 | 100.00% | 0 |
| PQ2307002200 | 61 | 61 | 100.00% | 0 |
| PQ2307002200 | 60 | 60 | 100.00% | 0 |

Figure 6. *Initial Production Batches Using Test Bridge (no cracked caps observed)*

To institutionalize this improvement, procedural documentation (JOV-2D0-58B/3015 Work Instruction) was revised to reflect the new setup. The previous single-point Contact Blocker was upgraded to a two-layer system incorporating the Test Bridge, which distributes force more evenly. Screwing is now performed on top the bridge structure. See Figure 7.

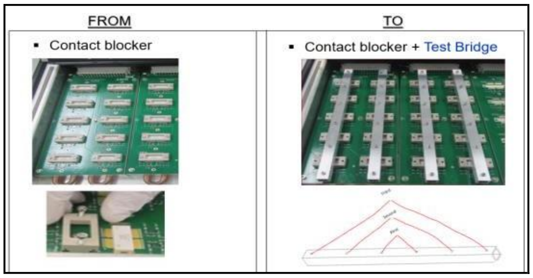



Figure 7. *Document Updates Reflecting Test Bridge Configuration*

The number of screws was also optimized as part of the implementation. The updated configuration required fewer screws to achieve mechanical stability, contributing to process efficiency. See in figure 8

| FROM | TO |
|---|---|
| ▪ Set screws per blocker , total of 80pcs (40x2).<br>40pcs - total number of contact blocker.<br>2pcs. - screw per contact blocker | ▪ Screwing is on the test bridge, total of 48pcs (6x8).<br>6pcs - screws per test bridge<br>8x lines |

Figure 8. *Number of Screws Before and After Test Bridge Implementation*

The electrical response of the units following the Burn-In test was evaluated during the DC2 test stage, where the Vgsth parameter serves as the key electrical indicator corresponding to Burn-In performance. Measurements were obtained using DC test equipment. DC2 Test yield summary as shown in Figure 9, five lots (totaling 301 units) were processed using the Test Bridge, all achieving a 100% yield with respect to Vgsth parameter.

| Lot | Qty In | Qty Out | Yield (%) |
|---|---|---|---|
| PQ2307002200 | 60 | 60 | 100% |
| PQ2307002100 | 60 | 60 | 100% |
| PQ2307002400 | 60 | 60 | 100% |
| PQ2307002000 | 61 | 61 | 100% |
| PQ2307002300 | 60 | 60 | 100% |
| | 301 | 301 | 100.00% |

Figure 9. *DC2 Test yield with respect to Vgsth parameter after implementation of Test bridge*

Figures 10 to 12 illustrate the Vgsth trend across the tested lots. The results show no electrical anomalies or parameter shifts following the implementation of the Test Bridge.

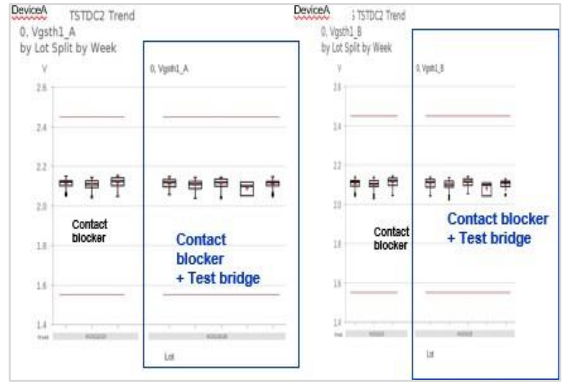



Figure 10. *Vgsth1_A/B: Comparable response*

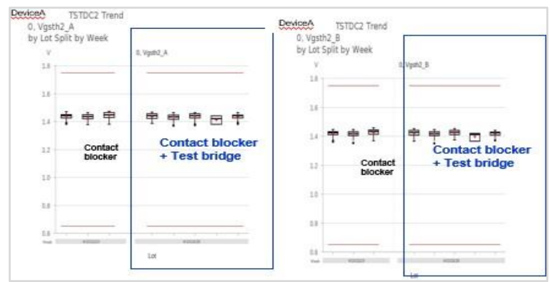



Figure 11. *Vgsth2_A/B: Comparable response*

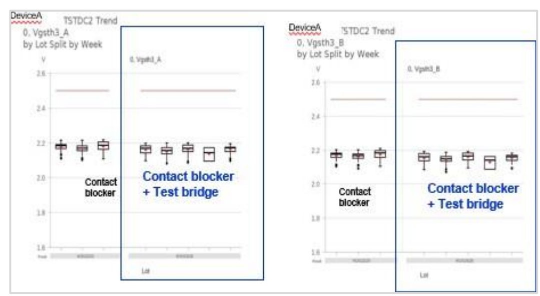



Figure 12. *Vgsth3_A/B: Comparable response*

A time study was conducted by IE to evaluate the impact of the Test Bridge implementation on process efficiency. Results showed an 8% improvement in Units Per Hour (UPH), primarily attributed to reduced time in the screwing and unscrewing steps. Specifically, the average time for "Tightening Screw" and "Unlock and Unscrew" decreased significantly—from 15.7 to 5.2 seconds and 11.5 to 7.7 seconds, respectively. These improvements contributed to a lower total inline time and a more streamlined operation, validating the Test Bridge's role in enhancing productivity.

| Work Element | | Ave. Time/unit (sec) |
|---|---|---|
| Offline | Camstar In | 0.5 |
| Inline | Load units | 12.2 |
| Inline | Position contact blocker | 10.0 |
| Inline | Tightening Screw | 15.7 |
| Inline | Close and Start | 0.5 |
| Inline | Burn-In Process | 315.0 |
| Inline | Unlock and Unscrew | 15.2 |
| Inline | Unload | 9.6 |
| Offline | Update Run card | 0.7 |
| Offline | Camstar Out | 0.5 |
| | MACHINE TIME/LOAD - miunutes | 210 |
| | LOAD/UNLOAD TIME/LOAD - minutes | 42 |
| | TOTAL TIME PER LOAD of 40 units - minutes | 252 |
| | G1 UPH | 8.6 |

| Work Element | | Ave. Time/unit (sec) |
|---|---|---|
| Offline | Camstar In | 0.5 |
| Inline | Load units | 7.0 |
| Inline | Position contact blocker | 9.0 |
| Inline | Tightening Screw | 5.2 |
| Inline | Close and Start | 1.7 |
| Inline | Burn-In Process | 315.0 |
| Inline | Unlock and Unscrew | 7.7 |
| Inline | Unload | 5.2 |
| Offline | Update Run card | 0.7 |
| Offline | Camstar Out | 0.5 |
| | MACHINE TIME/LOAD - miunutes | 210 |
| | LOAD/UNLOAD TIME/LOAD - minutes | 24 |
| | TOTAL TIME PER LOAD of 40 units - minutes | 234 |
| | G1 UPH | 9.3 |
| | % IMPROVEMENT FROM BASELINE | 8% |

Figure 13. *IE Time Study assessment before and after Test bridge implementation*

Overall, the objective of this study was to identify and eliminate cracked caps in ACC packages during the Burn-in Test. The motivation arose from a production yield drop to 66%, which was traced to the manual application of non-uniform force. After implementing the Test Bridge, the results clearly showed no further occurrences of cracked caps, confirming the hypothesis that uneven force distribution was the primary cause of failure. Additionally, UPH improved by 8% due to reduced screwing and unscrewing times, while electrical performance remained consistent with baseline parameters (Vgsth1/2/3), confirming that the mechanical change had no negative electrical impact. These results validate the Test Bridge as an improvement in both mechanical reliability and production efficiency, fully aligned with the original objective of increasing yield and supporting production readiness.

## 5.0 CONCLUSION

The implementation of a Test Bridge in the Burn-In Test setup successfully eliminated cracked ceramic caps in ACC packages, addressing a major source of yield loss. This solution introduced a more controlled and planar force application without requiring modifications to the existing contact Blocker. Beyond the yield improvement, it also enabled higher throughput and consistent electrical integrity. This design serves as a model for similar mechanical challenges in other sensitive package types.

## 6.0 RECOMMENDATIONS

Taking all the results into consideration, the data clearly demonstrates that the Test Bridge design has effectively addressed the root cause and eliminates the cracked ceramic caps during burn-in testing. This improvement not only validated the solution through measurable outcomes but also confirmed the design's readiness for full-scale production deployment.

## 7.0 ACKNOWLEDGMENT

The authors would like to thank the whole Test Engineering family. Special thanks to our Nijmegen counterpart specifically for Mechanical Design Team for the entire support.

**To God be all the Glory**

## 8.0 REFERENCES

[1] A. J., *The Essentials of Mechanical Stress Analysis.*
[2] K. Caraig, *Prototyping Mechanical Design Fundamentals.*
[3] J. A. Reyes and M. E. Santos, *Principles of Testing*, Manila, Philippines: Gordon Pub. Co., 1989, pp. 8–6.

## 9.0 ABOUT THE AUTHORS

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