TESTING PROCESS ROBUSTNESS: ELIMINATION OF POTENTIAL MIXING CUSTOMER COMPLAIN THROUGH ERROR PROOFING METHODOLOGY

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ABSTRACT

This paper will discuss how 2D code scanning sequence was modified to eliminate potential mixing issues that may lead to future customer complaints. Study happens during Benchmarking on other ST site as part of the technology preparation transfer. Using Error Proofing Methodology, Instrip Handler from Original Equipment Manufacturer was not able to consider on how to error proof the design location of 2D code reader that could induce undetected mixing issue caused by unintentional strip swapping during strip jamming and equipment error clearing.

2D code scanner was relocated into the correct machine area based on thorough analysis of strip handling flow. A modified 2D code scanning sequence prevented the strip with incorrect downloaded map from ALPS server to proceed with testing.

1. 0 INTRODUCTION

Micro-Electrical Mechanical Sensor (MEMS) package is one of the company's volume production runner. These products are tested on Strip form using substrate material. Each substrate has a unique 2D code engraved with alpha-numeric characters used as identification all throughout the process. All strips must undergo 2D code scanning before it can start testing. Once 2D code is scanned, strip map will be downloaded electronically on handler to start testing until it finished testing and upload back the map result to ALPS server. This procedure is simultaneously performed until it finished all strip testing as shown in Figure 1.

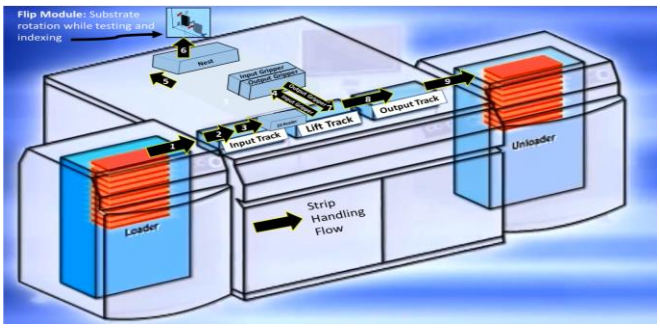


Fig. 1. Strip Handling Flow

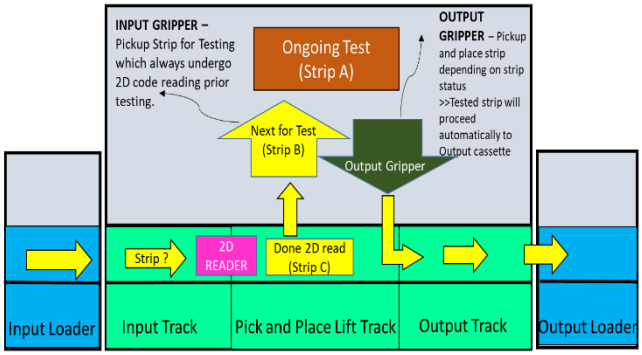


Fig. 2. Strip 2D Code Scanning Sequence Flow

Above shows how the current 2D code scanning sequence.

1) Strip identification is unknown until it passes through the 2D code scanner. Once it reads the 2D code, the handler will display the equivalent strip ID.
2) *Strip A* undergone 2D code scanning will perform strip and contactor fiducial alignment inspection. Once vision is Passed, strip map will be downloaded from ALPS server to handler for strip testing.
3) *Strip B* undergone 2D code scanning will be clamp by Input Gripper waiting for Strip A to finish testing (map is pre-downloaded from ALPS server).
4) *Strip C* which also undergone scanning will wait at Pick and Place Lift Track until Strip A is unloaded to cassette. (Map is not pre-downloaded yet from ALPS server).
5) Once *Strip A* is finished, Strip B will undergo vision inspection and move for Test while Strip C is waiting Strip B to finish testing (Strip C map is now pre-downloaded from ALPS server).

2. 0 REVIEW OF RELATED WORK

Checking from other previous studies related to anti-mixing, there are no studies or projects done related to the current design on Instrip Handler 2D Code scanning sequence flow. This is in reference to ST Calamba and other site who is using same model of Instrip Handler.

3.0 METHODOLOGY

3.1 Understanding the 2D Code Scanning Sequence Flow:

3.1.1 Step-by-step 2D Scanning Sequence installed Before Pick and Place Track (OEM Design) as shown in Figure 3

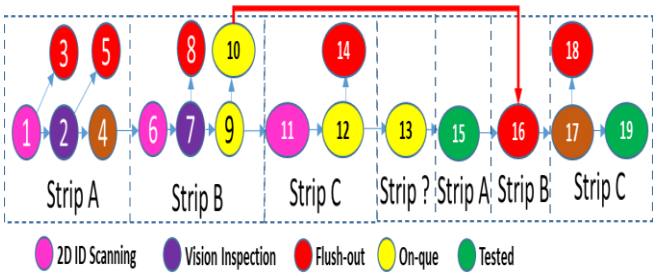


Fig. 3. Scanning Sequence Installed Before Pick and Place Track (OEM Design)

1) Strip A will proceed to 2D code scanning.
2) If 2D Passed, it moves to Pick and Place Lift Track and pick up by Input gripper to undergo vision fiducial inspection.
3) If 2D Fail, Strip A will be flush-out for manual removal inside the handler.
4) If Strip A passed vision fiducial, it will proceed testing.
5) If Strip A failed vision fiducial, Input gripper will place the Strip A on the nest and pick-up by Output gripper from the nest to unload the strip to flush-out for manual removal inside the handler.
6) Simultaneously, Strip B will proceed to 2D ID scanning.
7) If strip B passed 2D ID scanning, it moves to Pick and Place Lift Track and pick up by Input gripper to undergo vision fiducial inspection.
8) If strip B failed 2D ID scanning, Strip B will be flush-out for manual removal inside the handler.
9) If vision Passed, Strip B will on-que for next test waiting Strip A to finish testing and unload to cassette normally.
10) If vision fails, Strip B will wait for Strip A to finish testing before it can flush-out for manual removal inside the handler.
11) Simultaneously, Strip C will proceed to 2D ID scanning.
12) If 2D passed, strip C will be on-que at Pick and Place Lift Track for vision inspection awaiting Strip B to undergo testing.
13) **Strip ?** is on-que at Input track for 2D Scanning.
14) If 2D fail, strip C will be flush-out for manual removal inside the handler.
15) Tested Strip A will be placed on nest and Output gripper will pick-up the strip to move into unloader cassette.
16) Vision failed Strip B will place them on the nest and pick-up by Output gripper to flush-out for manual removal inside the handler.
17) If Strip C passed vision fiducial, it will proceed testing.
18) If Strip C failed vision fiducial, Input gripper will place the Strip C on the nest and pick-up by Output gripper from the nest to unload the strip to flush-out for manual removal inside the handler.
19) Tested Strip C will be placed on nest and Output gripper will pick-up the strip to unload on cassette normally.

Notes:

During this time, 4 strips are inside the handler – Strip A, B, C and Strip? that has not yet undergone 2D ID scanning.

Fourth strip ? will only undergo 2D ID scanning if strip A is already unloaded to cassette.

Strip C that undergone 2D scanning is on-que on lift track awaiting Strip A to be unloaded and so on.

However, if Strip A,B or C encounters strip jamming, vision fail or any handling error issue, strip will be aborted and remove manually inside the handler (red box in Figure 4 is accessible thru interlock door opening.

Analyzing the strip handling flow inside the handler, there is a potential cause of mixing thru strip swapping which can possibly happen and cannot be detected by in-placed control on the system as shown in Figure 4.

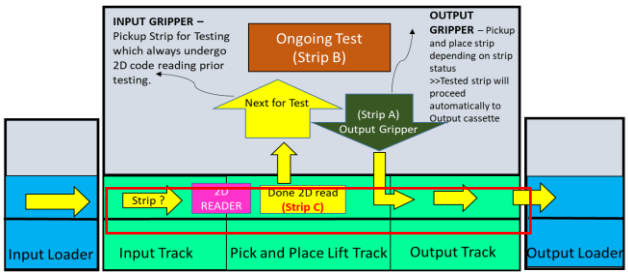


Fig. 4. Potential Mixing Scenario

3.1.2 Step-by-step 2D Scanning Sequence on how strip mixing can happen as shown in Figure 5.

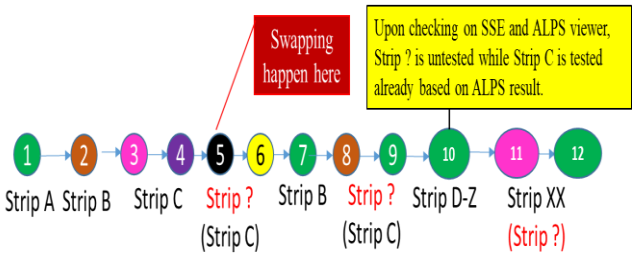


Fig.5. Step-by-step Potential Mixing Scenario

1) Strip A, done testing, pick-up by output gripper and proceed to unloader cassette.
2) Strip B undergo vision inspection and move for Test.
3) Strip C passed 2D ID scanning and move to Pick and Place Lift track.
4) Strip C for vision inspection is pick-up by Input Gripper, however strip C encountered clamping error and cannot pick-up strip despite few retries.
5) ***Operator unintentionally remove manually Strip C and replaced by Strip ? taken from input track*** **(strip can be swap since it is operator accessible via door interlock button)**
6) Strip ? clamped successfully by Input Gripper waiting Strip B to finish testing (however, Strip C map pre-downloaded from ALPS server will be used for Strip ? during testing).
7) Strip B done testing, pick-up by output gripper and proceed to unloader cassette.
8) Strip ? undergo vision inspection and move for Test.
9) Strip ? done testing, pick-up by output gripper and proceed to unloader cassette (***actual map used and downloaded for Strip ? is from Strip C!)***
10) The rest of the strip on the lot successfully tested. Upon checking on tested strip summary and ALPS viewer, Strip ? is untested while Strip C is tested already based on ALPS uploaded map result.
11) Operator reloaded Strip ? and undergo 2D ID scanning, later identified Strip XX.
12) Strip XX was successfully tested and was unloaded to unloader cassette.

In reality, Strip ? and later identified as Strip XX was TESTED TWICE while Strip C was NOT ACTUALLY TESTED >> mixing not detected by the system control!

Without further issue, the lot was released and endorsed to next station. With this potential cause of strip mixing which cannot be detected by the system, the team performed brainstorming on how to prevent the mixing strip inside the handler.

To prevent the potential mixing during strip handling, the following actions was identified for validation:

1) Disable manual input on 2D ID.
2) Enable interlock on Lift track to restrict from opening.
3) Software modification to flush out strip with handling error.
4) 2D ID Scanning sequence modification

Table 1. Actions for Verification Result

Actions	Verification	Remarks
Disable manual input on 2D ID	Manual 2D ID encoding is disabled by default.	Not Applicable
Enable interlock on Lift track to restrict operator from opening	Interlock is enabled; however, technician and operator need access on repair and clearing jams.	Not Applicable
Software modification to flush out strip with handling error	Handler software is equipped with flushing out the strip with errors inside the machine.	Not Applicable
2D ID Scanning sequence modification	2D ID Scanning sequence can be modify however it requires scanner relocation	For Validation

3.2 Experimentation Strategy:

1.) Relocate 2D ID Scanner in front part of the Pick and Place Lift Track as shown in Figure 6.

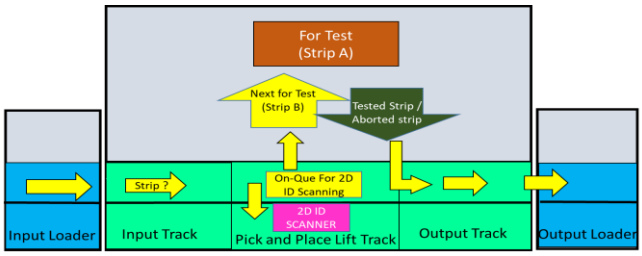


Fig. 6. 2D ID Scanner in front of PnP Lift Track

Fig. 7. Actual Lay-out of Proposed 2D ID Scanner in front of PnP Lift Track

3.2.1 Step-by-step Scanning Sequence if 2D Scanner is in Front of Pick and Place Lift Track as shown in Figure 8.

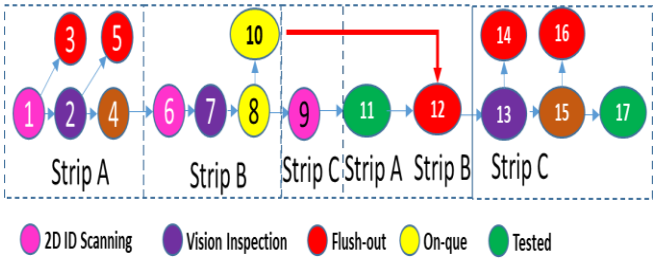


Fig. 8. Scanning Sequence in front of Pick and Place Track

1. Strip A will pick-up on lift track by Input gripper and proceed to 2D ID scanning.
2. If 2D passed, the strip will undergo vision fiducial inspection.
3. If 2D fail, input gripper will place strip on nest and Output gripper will pick-up from the nest and flush-out the strip.
4. If Strip A passed vision fiducial, it will proceed testing.
5. If Strip A failed vision fiducial, Input gripper will place the Strip A on the nest and pick-up by Output gripper from the nest to unload the strip to flush-out.
6. Strip B will be picked up by Input gripper to undergo 2D ID scanning.
7. If strip B passed 2D ID scanning, it will undergo vision fiducial inspection.
8. If vision Passed, Strip B will on-que for next test waiting Strip A to finish testing.
9. Strip C will move to Pick and Place lift track on que for 2D ID scanning.
10. If vision fail, Strip B will wait for Strip A to finish test.
11. Tested Strip A will be placed on nest and Output gripper will pick-up the strip to move into unloader cassette.
12. Vision failed Strip B will place the on the nest and pick-up by Output gripper to flush-out for manual removal inside the handler.
13. If 2D passed, strip C will undergo vision fiducial inspection.
14. If 2D fail, input gripper will place strip on nest and Output gripper will pick-up from the nest and flush-out the strip.
15. If Strip C passed vision fiducial, it will proceed testing.
16. If Strip C failed vision fiducial, Input gripper will place the Strip C on the nest and pick-up by Output gripper from the nest to unload the strip to flush-out.
17. Tested Strip C will be placed on nest and Output gripper will pick-up the strip to move into unloader cassette.

Notes:

During this time, 4x strip is inside the handler – Strip A,B, ? on-que at Lift Track for 2D scanning and Strip ?? located at Input Track.

Third strip ? on-que at lift track will only undergo 2D ID scanning if Strip A is already unloaded to cassette.

Doing this sequence, there is no possibility that strip on lift track can escape testing with wrong 2D ID map downloaded from ALPS server >> scanned strip on input gripper is outright move inside the handler which cannot be access or swap manually.

2.) Relocate 2D ID Scanner After Pick and Place Lift Track as shown below.

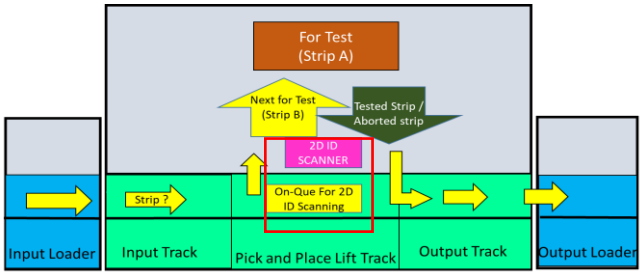


Fig. 9. 2D ID Scanner After Pick and Place Lift Track

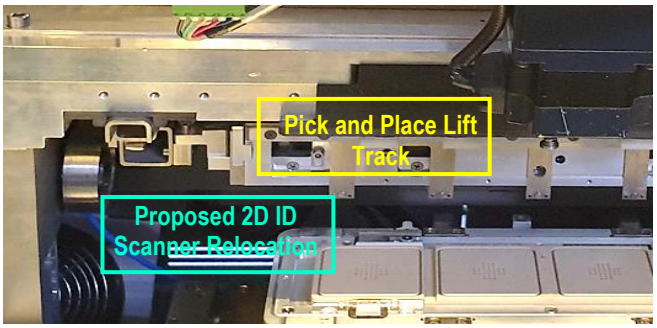


Fig. 10. Actual Lay-out Proposed 2D ID Scanner After Pick and Place Lift Track (View from the back)

3.2.2 Step-by-step Scanning Sequence if 2D Scanner After Pick and Place Lift Track as shown in Figure 11.

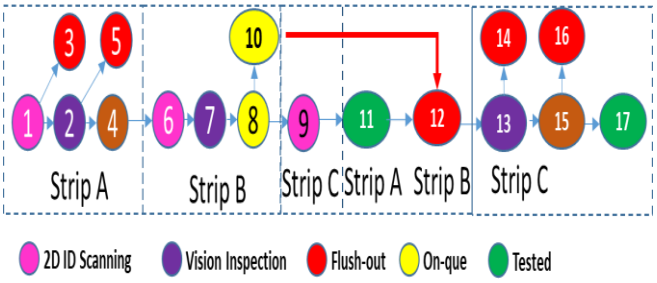


Fig. 11. Scanning Sequence After Pick and Place Lift Track

1. Strip A will be picked up on lift track by Input gripper and proceed to 2D ID scanning.
2. If 2D passed, the strip will undergo vision fiducial inspection.
3. If 2D fails, the input gripper will place strip on nest and Output gripper will pick-up and flush-out the strip.
4. If Strip A passed vision fiducial, will proceed testing.
5. If Strip A failed vision fiducial, Input gripper will place the Strip A on the nest and pick-up by Output gripper to unload the strip for flush-out.
6. Strip B will be picked up by the Input gripper to undergo 2D ID scanning.
7. If strip B passed 2D ID scanning, it will undergo vision fiducial inspection.
8. If vision Passed, Strip B will on-que for next test waiting Strip A to finish testing.
9. Strip C will move to Pick and Place lift track on que for 2D ID scanning.
10. If vision fail, Strip B will wait for Strip A to finish test.
11. Tested Strip A will be placed on nest and Output gripper will pick-up the strip to move into unloader cassette.
12. Vision failed Strip B will be pick-up by Output gripper to flush-out for manual removal inside the handler.
13. If 2D passed, strip C will undergo vision fiducial inspection.
14. If 2D fail, input gripper will place strip on nest and Output gripper will pick-up from the nest and flush-out the strip.
15. If Strip C passed vision fiducial, it will proceed testing.
16. If Strip C failed vision fiducial, Input gripper will place the Strip C on the nest and pick-up by Output gripper to unload the strip for flush-out.
17. Tested Strip C will be placed on nest and Output gripper will pick-up the strip to move into unloader cassette.

Notes:

During this time, 4x strip is inside the handler – Strip A,B, ? on-que at Lift Track for 2D scanning and Strip ?? located at Input Track.

Third strip ? on-que at lift track will only undergo 2D ID scanning if first strip is already unloaded to cassette.

Doing this sequence, there is no possibility that strip on lift track can escape testing with wrong 2D ID map downloaded from ALPS server >> scanned strip on input gripper is outright move inside the handler which cannot be access or swap manually.

In summary, both proposed location of 2D Scanner resulted in the same sequence on 2D scanning with no possibility that strip will be tested with incorrect map downloaded from ALPS server.

The following experimentation proposal was consulted to OEM Software and Hardware Team to check feasibility on 2D ID Scanning sequence modification.

Upon technical assessment from OEM, below are the results.

Table 2. Result of Experimental Scanner Relocation

Expt.#	2D Scanner Relocation	Remarks / Result
1	In-Front of Pick and Place Lift Track	Not Feasible due to Input gripper mechanical limitation - cannot reach target scanning position
2	After Pick and Place Lift Track	Feasible. Need to fabricate mounting assembly to install 2D Scanner.

3.3 Validation Method:

Using the 2D Scanner installed Before Pick and Place Lift Track, load 4x dummy strip inside the handler and perform 2D Scanning.

1. Strip A to proceed with testing and Strip B to proceed vision inspection and on-que for testing.
2. Strip C on-que for Input Gripper pick-up at Lift.
3. Intentionally swap not undergone 2D Scan Strip ? into Strip C and check if the handler can detect the swapping done on strip.
4. Perform 20 run cycles and record the result.

Table 3. Result of Strip Swapping using 2D Scanner Installed Before Pick and Place Lift Track

Cycle Run#	Strip Swapping Detection (Strip ? and Strip C)	Result
1 -20	No error encountered.	Swapping was not detected and will lead to mixing strip.

With this validation result, it is recommended to modify the 2D ID scanning sequence through relocation of 2D Scanner. 2D Scanner is recommended to transfer from Before Pick and Place Lift Track to After Pick and Place Lift Track as shown in Figure 12

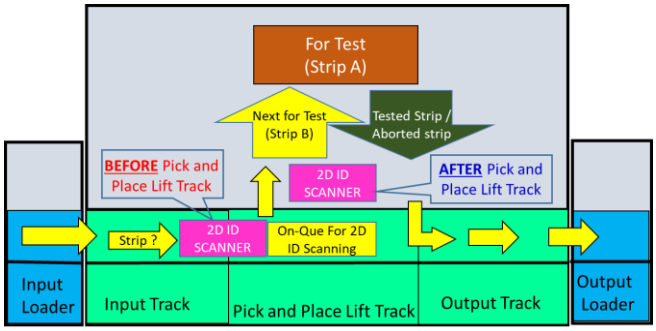
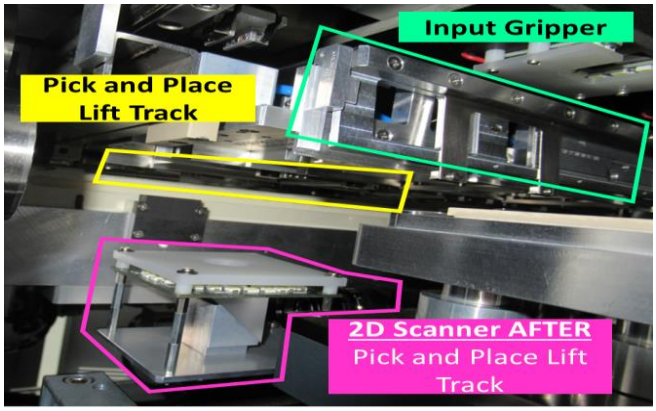


Fig. 12. 2D Scanner Relocation (Before and After)

Below is the actual 2D Scanner installed After Pick and Place Lift Track wherein strip is pick-up first by Input Gripper, move inside the handler for 2D scanning and outright stop on-que for vision inspection position once successfully scanned.



Using the 2D Scanner installed After Pick and Place Lift Track, load 4x dummy strip inside the handler and perform 2D Scanning.

1. Strip A to proceed with testing and Strip B to proceed vision inspection and on-que for testing.
2. Strip ? on-que for Input Gripper pick-up at Lift .
3. Intentionally swap not undergone 2D scan Strip ? into Strip B and check if handler can detect the swapping done on strip.
4. Perform 20 run cycles and record the result.

Table 4. Result of Strip Swapping using 2D Scanner Installed After Pick and Place Lift Track

Cycle Run#	Strip Swapping Detection (Strip ? and Strip B)	Result
1-20	Strips are not accessible	Swapping not possible

Below is the Statistical Testing done to check if the new scanner location is better than the old location.

Process Function	Process Step	Practical Problem	Test Plan
Multi Tester	2D Barcode Scanning	Is the new 2D Barcode Scanner location (After PnP) better than the Old location (Before PnP)?	2-proportion

Hypothesis Statement	Conclusion
Ho: $P_{New\ location} = P_{Old\ location}$ Ha: $P_{New\ location} > P_{Old\ location}$	P value< 0.05 Reject Ho

2D Scanner Location	Run Result (2D Scanning)	Data
Before PnP Lift Track	No Mixing Strip	0
Before PnP Lift Track	With Mixing Strip	20
After PnP Lift Track	No Mixing Strip	20
After PnP Lift Track	With Mixing Strip	0

Freq: Data

Contingency Table

2D Scanner Location	Count / Total % / Col % / Row %	No Mixing Strip	With Mixing Strip	Total
After PnP Lift Track		20 50.00 100.00 100.00	0 0.00 0.00 0.00	20 50.00
Before PnP Lift Track		0 0.00 0.00 0.00	20 50.00 100.00 100.00	20 50.00
Total		20 50.00	20 50.00	40

Run Result (2D Scanning)

Contingency Analysis of Run Result (2D Scanning) By 2D Scanner Location

Mosaic Plot

Tests

N	DF	-LogLike	RSquare (U)
40	1	27.725887	1.0000

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	55.452	<.0001*
Pearson	40.000	<.0001*

Fisher's Exact Test	Prob	Alternative Hypothesis
Left	1.0000	Prob(Run Result (2D Scanning)=With Mixing Strip) is greater for 2D Scanner Location=After PnP Lift Track than Before PnP Lift Track
Right	<.0001*	Prob(Run Result (2D Scanning)=With Mixing Strip) is greater for 2D Scanner Location=Before PnP Lift Track than After PnP Lift Track
2-Tail	<.0001*	Prob(Run Result (2D Scanning)=With Mixing Strip) is different across 2D Scanner Location

Practical Conclusion:

- *Run Results are different between the designs.*
- *At better than 95% confidence level, New location of 2D Code Scanner (After Pick and Place Lift Track) will result to low risk of strip mixing.*

4.0 RESULTS AND DISCUSSION

After changing the location of 2D Scanner to After Pick and Place Lift Track, potential strip mixing was prevented thru modified 2D Scanning Sequence due to following improvement:

1) Handling flow will not allow actual strip with incorrect downloaded map from ALPS server
2) Strip undergone 2D Scanning cannot manually remove and strip is not accessible if already pickup by input gripper inside the test handler.

Since the start of MEMS Instrip Testing in Calamba in November 2017 up to present, there is no occurrence of strip mixing nor customer complain recorded.

5.0 CONCLUSION

2D Scanning Sequence Modification through Scanner relocation is an effective way to error proof and prevent strip mixing.

6.0 RECOMMENDATIONS

It is recommended to fan-out this improvement on upcoming machines with the same platform.

7.0 ACKNOWLEDGMENT

The authors would like to acknowledge the following: Multitest Software and Hardware Engineers for the technical guidance and feasibility study.

8.0 REFERENCES

1. Multitest Instrip Handler Manual

2. Conversion Kit Manual

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