SE 300 Solder Paste Inspection System
Gauge Repeatability and Reproducibility Procedure and Results

Background

Any time a process is measured there is some variation. This variation comes from two sources: one, there are always differences between the parts made; and two, every method of taking measurements is imperfect (i.e. measuring the same part repeatedly does not result in identical measurements). Gauge R&R is used to determine what portion of the variability in measurements is due to the measurement system.

Measurement system variability includes both variation due to the gauge (repeatability) and operator-to-operator variability (reproducibility). In a typical Gauge R&R study, 3 operators will make 3 measurements each on 10 different parts. The sources of variation (measurement system, operator, or part-to-part) are quantified by the analysis of the measurement results.

The SE 300 is an automated measurement system that has no operator influence. Therefore, the Gauge R&R test described here is such that the repeated loading of the boards yields a reproducibility figure (instead of an operator influence).

Test Vehicle and Setup

Test Panel and Printing

- Panel: 0.62 inch thick, 2 board/panel, White-Tin finish, FR4 substrate with green LPI solder mask.
- Printer: MPM AP-25, metal squeegee
- Solder Paste: Type 4, 63/37, AIM WS483 (water soluble)
- Stencil: 3 mil thick, EFAB technology from Photo Stencils Inc.

Inspection System

- SE 300 rel 1.0 software
- Conveyors In Simulate Mode
  Conveyor Simulate Mode is a state in which the machine does not release the board following an inspection, but it continues to repeatedly inspect the same board until the pause or stop buttons are pressed.

Inspection Program

SRF (Standard Recipe File) taught to inspect multiple pads and locations from each board. See Figure 1.

- 8 mil dia. BGA; U33, and U37 (576 pads)
- 10 mil dia. BGA; U32, U34, and U38 (312 pads)
- 12 mil dia. BGA; U15 (416 pads)
- 15 mil dia. BGA; U100 (512 pads)
- 25 mil dia. / 50 mil pitch BGA; U36, and U42 (1568 pads)
- 16 mil pitch QFP; U26, U27, and U28 (600 pads)
- 0402s; multiple resistors (284 pads)
- Additionally, 3 fiducials were taught per board.

All inspected tasks need to have the “log traces” check box checked

Notes:

a.) Inspected pads must meet the minimum paste height requirement of 2 mils to be included in the Gauge R&R study

b.) Candidates for 8 mil diameter paste may require 10 mil diameter apertures to achieve acceptable 8 mil diameter prints.

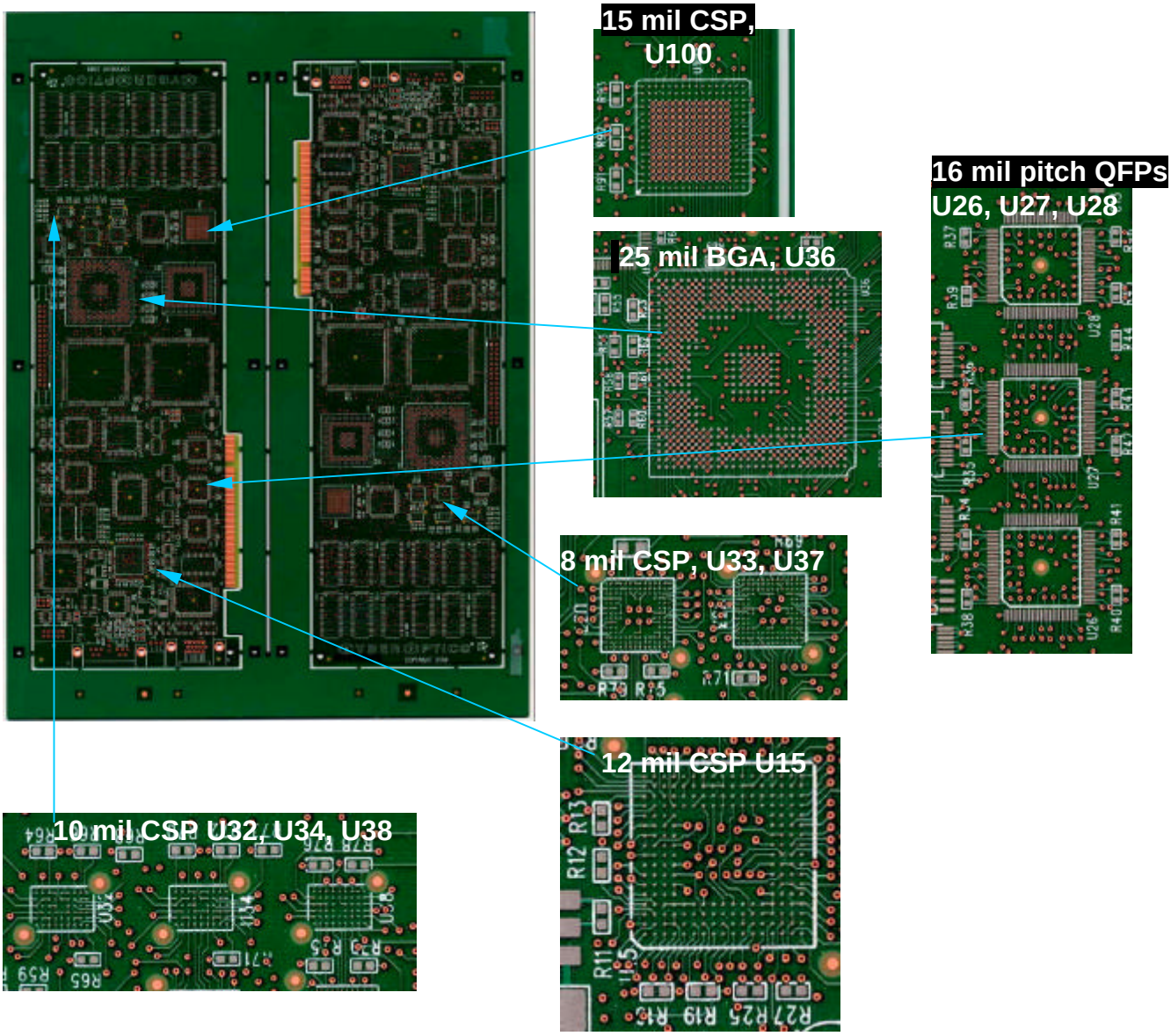

Figure 1. Picture of a Test Panel

Data Collection Process

1. Select option for data-logging to a .CSV file
2. Run reference scan without collecting offsets. This can be done on a bare board or on the test panel. If offsets are collected, however, a bare board must be used.
3. Load the Panel.
4. Inspect per the SRF. Logging data on all pads. (note: SRF trained to inspect all pads in both high resolution and high speed mode)
5. Loop through inspection three times.
6. Repeat steps 3-5, two more times. This way each of the pads is inspected nine times.

Note:
Instead of actually reloading the board at step 3 every time, the board was manually repositioned at the same place (+/- .25"))

Data Analysis

Gauge R&R Method: X bar and R (Commonly used Automotive Industry Action Group (AIAG) method). Separate Gauge R&R analyses are performed for Height and Volume for each pad size.

Specification Limits

Repeatability: Variation due to repeated trials
Reproducibility: Variation due to repeated panel loading
Gauge R&R: Square root of the sum of the squares of Repeatability and Reproducibility

The results are given as a percentage of a typical process tolerance. Tolerance is calculated using the average of all measurements (for height or volume) across all sites for a particular pad size.

Gauge R&R Specification for Height and Volume	High Speed Mode	High Resolution Mode
Typical Components[1]	< 15 %	< 10 %
CSPs[2]	Presence/Absence only	< 10 %

[1] GR&R for height and volume of a 30% process tolerance. Traditional component types including QFPs and BGAs (>= 20 mil diameter pads).
[2] GR&R for height and volume of a 50% process tolerance. CSP components with pads from 8 to 18 mils in diameter. Greater process tolerance used because CSP component solder balls are eutectic.

SE 300 High Resolution Mode Gauge Repeatability and Reproducibility Study Results

Pad Type	Number of pads	Measurement	Tolerance	Mean (mils)	Tolerance Range (mils)	Repeatability	Reproducibility	**Gauge R&R**	**Specification**
8 mil CSP	576	Height	+/- 50%	3.64	3.64	7.17%	0.78%	**7.21%**	**< 10%**
(U33, U37)		Volume	+/- 50%	146.6	146.6	8.62%	4.77%	**9.86%**	**< 10%**
10 mil CSP	312	Height	+/- 50%	4.18	4.18	4.63%	0.05%	**4.63%**	**< 10%**
(U32, U34, U38)		Volume	+/- 50%	301.5	301.5	6.00%	1.85%	**6.28%**	**< 10%**
12 mil CSP	416	Height	+/- 50%	3.70	3.70	4.09%	0.26%	**4.10%**	**< 10%**
(U15)		Volume	+/- 50%	362.9	362.9	5.78%	2.54%	**6.32%**	**< 10%**
15 mil dia CSP	512	Height	+/- 50%	3.45	3.45	3.30%	0.47%	**3.33%**	**< 10%**
(U100)		Volume	+/- 50%	556.1	556.1	4.13%	1.98%	**4.58%**	**< 10%**
25 mil BGA	1586	Height	+/- 30%	3.94	2.36	3.29%	0.12%	**3.29%**	**< 10%**
(U36,U42)		Volume	+/- 30%	1812.2	1087.3	4.18%	0.44%	**4.21%**	**< 10%**
16 mil pitch QFP	600	Height	+/- 30%	3.97	2.38	3.62%	0.29%	**3.63%**	**< 10%**
(U26, U27, U28)		Volume	+/- 30%	2313.2	1.387.9	5.21%	0.52%	**5.24%**	**< 10%**
0402s (32x30 mil)	284	Height	+/- 30%	4.18	2.51	3.29%	0.28%	**3.30%**	**< 10%**
Pads, Resistors)		Volume	+/- 30%	3790.3	2274.2	4.21%	2.50%	**4.89%**	**< 10%**

SE 300 High Speed Mode Gauge Repeatability and Reproducibility Study Results

Pad Type	Number of pads	Measurement	Tolerance	Mean (mils)	Tolerance Range (mils)	Repeatability	Reproducibility	**Gauge R&R**	**Specification**
8 mil CSP	576	Height	+/- 50%	3.54	3.54	14.44%	1.99%	**14.57%**	**Presence/Absence**
(U33, U37)		Volume	+/- 50%	159.7	159.7	18.20%	2.70%	**18.40%**	**Presence/Absence**
10 mil CSP	312	Height	+/- 50%	4.13	4.13	8.82%	1.12%	**8.89%**	**Presence/Absence**
(U32, U34, U38)		Volume	+/- 50%	328.5	328.5	11.95%	2.86%	**12.28%**	**Presence/Absence**
12 mil CSP	416	Height	+/- 50%	3.66	3.66	7.83%	1.49%	**7.97%**	**Presence/Absence**
(U15)		Volume	+/- 50%	389.4	389.4	10.81%	2.92%	**11.20%**	**Presence/Absence**
15 mil dia CSP	512	Height	+/- 50%	3.43	3.43	6.00%	0.22%	**6.01%**	**Presence/Absence**
(U100)		Volume	+/- 50%	580.8	580.8	7.76%	1.03%	**7.83%**	**Presence/Absence**
25 mil BGA	1586	Height	+/- 30%	3.94	2.37	5.82%	1.87%	**6.11%**	**< 15%**
(U36,U42)		Volume	+/- 30%	1581.8	1111.1	7.71%	2.20%	**8.01%**	**< 15%**
16 mil pitch QFP	600	Height	+/- 30%	3.97	2.38	5.95%	2.23%	**6.35%**	**< 15%**
(U26, U27, U28)		Volume	+/- 30%	2437.0	1462.2	8.53%	1.65%	**8.68%**	**< 15%**
0402s (32x30 mil)	284	Height	+/- 30%	4.19	2.52	5.53%	1.73%	**5.79%**	**< 15%**
Pads, Resistors)		Volume	+/- 30%	3.883.3	2330.0	7.29%	1.10%	**7.37%**	**< 15%**