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**LABORATORY TEST REPORT: EL 2005-06-005 Rev. 1** **Requested By: D. Harper**
**Tested By: G. McNelly** **Dates Tested: 11/18/05 - 2/21/06**
**Reported By: _____** **Date: 3/31/06**
J. A. Kopec - Staff Product Test Engineer

**SUBJECT: GIG-Array® Lead Free Qualification Testing–Vibration, Shock, 3 Point Bend, Temp Cycling**

## PURPOSE

This report summarizes the qualification testing performed on the FCI lead free GIG-Array connector system possessing 30 µ" Au plating on both plug and receptacle contacts. Testing consisted of a vibration and mechanical shock sequence with durability cycling and dust application and the 3 point bend test in accordance with FCI product specification GS-12-192, rev. C. This report was amended at revision 1 to include the accelerated temperature cycling which was performed at a later date than the vibration, shock, and 3 point bend tests.

## CONCLUSIONS:

All samples of both 200 position 28mm and 296 position 35mm sample groups successfully completed the vibration and mechanical shock test sequence. All LLCR was below specification maximums both initially and throughout the test sequence. No discontinuities >1 µs were observed during vibration and mechanical shock. All samples of both sample groups also successfully complete 2670 accelerated temperature cycles without any observed solder joint failure.

## SAMPLE DESCRIPTION:

| | |
|---|---|
| 200 pos, 13 mm plug | FCI 10030626-001LF, lot # 518618x1 |
| 200 pos, 15 mm receptacle | FCI 55741-001LF, lot # 518618x2 |
| 296 pos, 20 mm plug | FCI 55727-001LF, lot # 518618x3 |
| 296 pos, 15 mm receptacle | FCI 55733-001LF, lot # 518428x1 |
| Plug LLCR test board | SK53414 |
| Receptacle LLCR test board | SK52294 |
| 200 pos plug continuity test board | SK10061178 |
| 200 pos rec. continuity test board | SK10061177 |
| 296 pos plug continuity test board | SK52091 |
| 296 pos rec. continuity test board | SK52090 |

All samples were received in the test lab 6/2/05 and deemed suitable for testing by a member of the test lab staff. Soldering of samples to test boards was performed by product engineering using a convection oven reflow machine.

## TEST GROUP 4 – VIBRATION & MECHANICAL SHOCK

Test group 4 sequence consisted: ½ of the rated durability cycles (rating = 25 cycles), application of dust to unmated plugs only, vibration, mechanical shock, and the remaining ½ of the durability cycles. Low level contact resistance (LLCR) was measured initially, after 13 total durability cycles, after dust, after vibration, after shock, and after 25 total durability cycles. Sample size consisted of 5 mated pair connectors of both 200 position and 296 position samples assembled to LLCR test boards and another 5 mated pair of both sizes assembled to continuity test boards.

Durability cycles were applied in accordance with EIA 364-09C using an Instron compression/tensile tester. Dust was applied in accordance with EIA 364-91A to unmated plugs for 1 hour using dust composition #1 (benign). Sinusoidal vibration was performed at 10g for 8 hours on each of 3 axes in accordance with EIA 364-28D. Mechanical shock was performed at 30g, 11ms, ½ sine pulse in accordance with EIA 364-27B. Three shocks were performed in each direction on each of 3 axes (18 shocks total). All LLCR measurements were performed in accordance with EIA 364-23, (12/00) except thermal Electromotive Force (EMF) is automatically corrected by the Keithley 580 micro-ohmmeter. For continuity samples, an event detector was utilized to detect resistance changes greater than 10 ohms for 1 μs or longer.

Vibration & Mechanical Shock Results

All continuity samples successfully completed the test sequence without any discontinuities greater than 1 μs. All LLCR samples also successfully completed the test sequence. Both signal and ground contacts of both sizes were below their respective maximum allowable initial LLCR and far below the maximum allowable increase in resistance (10 mΩ) throughout the test sequence. Tables 1 through 4 summarize the LLCR results. All values reported in the table are change in LLCR except for the initial measurement, which is the actual measured LLCR.

### TABLE 1 – 200 POSITION, 28 MM GROUND LLCR DELTAS

| Statistic | Initial | 13 Cycles | Dust | Vibration | Shock | 25 Cycles |
|---|---|---|---|---|---|---|
| Average | 10.19 | -0.53 | -0.62 | -0.73 | -0.83 | -0.96 |
| Minimum | 6.75 | -5.23 | -6.25 | -6.07 | -6.25 | -6.84 |
| Maximum | 17.06 | 1.69 | 0.57 | 0.24 | 0.17 | 0.34 |
| Std Dev | 1.68 | 0.79 | 0.75 | 0.77 | 0.77 | 0.87 |
| Count | 170 | 170 | 170 | 170 | 170 | 170 |
| # > 31 | 0 | N/A | N/A | N/A | N/A | N/A |
| # > 10 | N/A | 0 | 0 | 0 | 0 | 0 |

### TABLE 2 – 200 POSITION, 28 MM SIGNAL LLCR DELTAS

| Statistic | Initial | 13 Cycles | Dust | Vibration | Shock | 25 Cycles |
|---|---|---|---|---|---|---|
| Average | 11.09 | -0.25 | -0.23 | -0.32 | -0.37 | -0.49 |
| Minimum | 9.36 | -1.97 | -2.02 | -2.02 | -2.16 | -3.13 |
| Maximum | 13.95 | 0.57 | 0.48 | 0.23 | 0.17 | 0.21 |
| Std Dev | 0.89 | 0.35 | 0.30 | 0.30 | 0.30 | 0.41 |
| Count | 340 | 340 | 340 | 340 | 340 | 340 |
| # > 31 | 0 | N/A | N/A | N/A | N/A | N/A |
| # > 10 | N/A | 0 | 0 | 0 | 0 | 0 |

## TABLE 3 – 296 POSITION, 35 MM GROUND LLCR DELTAS

| Statistic | Initial | 13 Cycles | Dust | Vibration | Shock | 25 Cycles |
|---|---|---|---|---|---|---|
| Average | 13.72 | -2.49 | -2.42 | -2.51 | -2.92 | -2.83 |
| Minimum | 7.64 | -20.67 | -19.79 | -19.48 | -20.94 | -20.69 |
| Maximum | 32.52 | 0.94 | 0.25 | 0.11 | 0.07 | 0.02 |
| Std Dev | 3.99 | 3.05 | 2.94 | 2.92 | 3.07 | 3.05 |
| Count | 250 | 250 | 250 | 250 | 250 | 250 |
| # > 36 | 0 | N/A | N/A | N/A | N/A | N/A |
| # > 10 | N/A | 0 | 0 | 0 | 0 | 0 |

## TABLE 4 – 296 POSITION, 35 MM SIGNAL LLCR DELTAS

| Statistic | Initial | 13 Cycles | Dust | Vibration | Shock | 25 Cycles |
|---|---|---|---|---|---|---|
| Average | 13.24 | -0.62 | -0.55 | -0.58 | -0.74 | -0.70 |
| Minimum | 11.29 | -3.02 | -3.01 | -3.10 | -3.22 | -3.20 |
| Maximum | 17.01 | 0.19 | 0.36 | 0.22 | -0.04 | -0.05 |
| Std Dev | 1.10 | 0.52 | 0.55 | 0.53 | 0.55 | 0.55 |
| Count | 500 | 500 | 500 | 500 | 500 | 500 |
| # > 36 | 0 | N/A | N/A | N/A | N/A | N/A |
| # > 10 | N/A | 0 | 0 | 0 | 0 | 0 |

## TEST GROUP 7 – ACCELERATED TEMPERATURE CYCLING

Accelerated temperature cycling was performed to evaluate the solder joint integrity of the solder ball-to-contact and solder ball-to-pcb pad interfaces. Temperature cycling was performed at Trace Laboratories, 1150 W. Euclid Ave, Palatine, IL 60067 under product test laboratory file EL-2005-06-006. Thirty mated pair of both sample groups were temperature cycled between 0C and +100C with 30 minute dwell at each temperature for 2670 cycles. Electrical resistance was monitored using an event detector for each ground and signal daisy chain circuit of each sample in accordance with IPC-9701 (1/02). An event was defined as an increase in resistance greater than 1000 ohms for periods of time greater than 200 nanoseconds. A failure was defined as an event followed by 9 additional events within 10% of the cycles from the initial event.

### Accelerated Temperature Cycling Results

All samples of the 200 position, 28mm samples (group 1) successfully completed 2670 temperature cycles with no events. Two samples of the 296 position, 35mm samples (group 2) exhibited electrical failure. Sample 2-4 exhibited electrical failure in the ground circuit at cycle #1070. Sample 2-14 exhibited electrical failure in the signal circuit at cycle #283.

Metallographic x-sections of samples 2-4 and 2-14 were prepared to determine if solder joint cracking caused the electrical failures. Each row of the daisy chain circuit exhibiting electrical failure of each sample was examined. Solder joint cracking was not observed in any of the failed samples. Root cause of the electrical failure could not be established from the x-sections. The only anomaly observed was a bent contact of one of the 2 tines comprising a signal contact in row S of sample 2-14. Figure 1 illustrates the observed bent contact.

FIG. 1 – BENT SIGNAL TINE, SPL. 2-14, ROW S

## TEST GROUP 8 – THREE POINT BEND

Test group evaluated the ball grid array (BGA) solder joint resistance to cracking when exposed to printed circuit board (PCB) deflections observed during typical PCB assembly and test operations. The 3 point bend test was performed in accordance with the product specification on 3 plugs and 3 receptacles of each size. The samples were assembled to a PCB and deflected using an Instron compression/tensile tester 0.020"/support span" as shown in figure 2. The product specification did not specify acceptance or failure criteria.

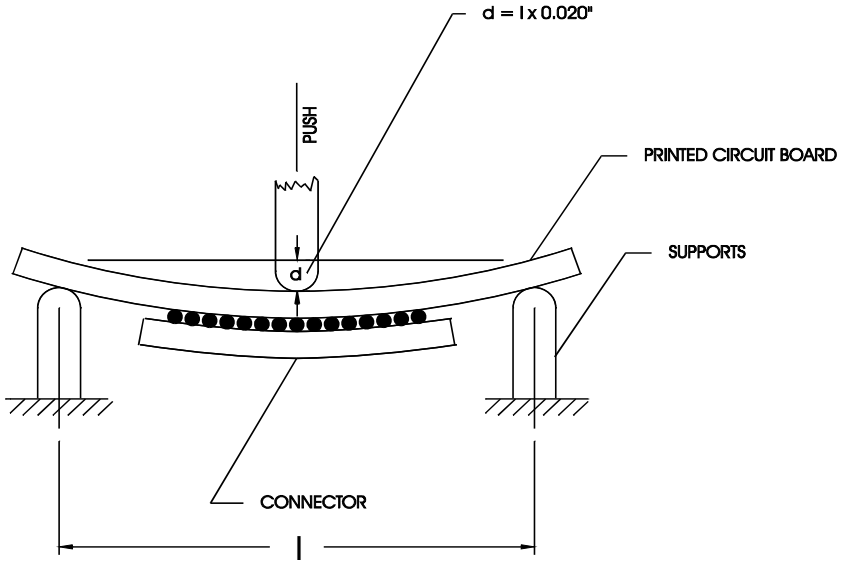


**FIG. 2 - 3 POINT BEND SET-UP**

After deflection, a marking dye was applied to the perimeter of the connector housing at the PCB interface. The samples were placed in a vacuum chamber to facilitate penetration of the marking dye into any solder joint cracks formed during deflection. After the marking dye dried, the samples were pried from the PCB. The samples were visually examined using a microscope at 10X to determine the type of crack observed (if any) and the approximate % dye observed in the cracked interface.

Three Point Bend Results

Three contacts of 200 position plug sample #1 exhibited marking dye in the solder ball-to-PCB interface. Position D13 exhibited 50% dye, D17 exhibited 10% dye, and F13 exhibited 80% dye. None of the other samples exhibited any cracking. The predominant failure mode observed when removing the connector from the PCB was PCB pad separation.

## EQUIPMENT

| ITEM NAME | MANUFACTURERS NAME | ID NUMBER | CALIBRATION DUE DATE |
|---|---|---|---|
| Compression/Tensile Tester | Instron | VG6461 | 8/06 |
| Load cell | Instron | VG6448 | 8/06 |
| Vibration Table | Unholtz-Dickie | VG7977 | N/C |
| Vibration Amplifier | Unholtz-Dickie | VG7976 | N/C |
| Vibration Controller | VR Scientific | VG7974 | 9/06 |
| Accelerometer | Endevco | VG7971 | 7/06 |
| Event Detector | Anatek | VG6090 | 4/06 |
| Shock Machine | Avex | VG7979 | N/C |
| Data Acquisition Adapter | National Instruments | VG7975 | 6/06 |
| Signal Conditioner | PCB | VG7969 | 8/06 |
| Connector Accessory | National Instruments | VG7973 | N/C |
| Accelerometer | PCB | VG7979 | 7/06 |
| Event Detector | Anatek | VG6861 | 8/06 |
| Micro-ohmmeter | Keithley | VG7393 | 3/06 |
| Channel Scanner | Keithley | Q316352 | N/C |
| | | | |
| | | | |
| N/C = Not calibrated<br>CBU = Calibrate Before Use | | | |