Introbotics CI1000 Metrology Capability Assessment

Date	March 10, 2006
Equipment	Introbotics CI1000 Automated Controlled Impedance Test System
Serial Number	0001
Location	Albuquerque, NM, USA

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General Description

The purpose of this assessment is to characterize the capability of the CI1000 located in Albuquerque, NM. The Assessment comprised three parts including "Accuracy", "Repeatability" and a "Reproducibility" carried out over three days. The CI1000 includes the following equipment:

Tektronix's TDS8000 Sampling Oscilloscope (Serial#B010530)
Tektronix 80E04 2-channel TDR Sampling Head (Serial B011206)
Muary Microwave Precision Airline (50.02 Ohms)
IBC100 Robotic Probe (Pitch: 100mil) (Calibration: Transfer standard value 49.05 ohms, 30%-50% Risetime Value 15 psec)
IBC100100 Robotic Probe (Differential Pitch: 100mil Square) (Calibration: Transfer standard value CH1, CH2: 50.03 Ohms, 49.98 Ohms; 30%-50% Risetime Values CH1, CH2: 10 psec, 11 psec)

System Calibration Description

The CI1000 system (including the specific probe) was calibrated utilizing the IPC TM-650 2.5.5.7 "Characteristic Impedance of Lines on Printed Boards by TDR" dated January 2004. The method utilized was the "Transfer Standard Method" (reference section 5.2.1 in IPC document). This method involves calibrating an in-line "transfer" standard (coax cable) utilizing the NIST calibrated Airline as the primary reference. The in-line transfer standard, mounted just adjacent to the probe is thus reference for each subsequent DUT measurement to ensure accuracy.

DUT Description

The Single-ended Device Under Test (DUT) utilized for the assessments was a 18" x 24" panel manufactured with Isola 620 material. The interconnects measured were designed as coupon structures about 12" long. The Differential Device Under Test (DUT) utilized for the assessments was a 12" x 9" panel manufactured with standard FR4 material. The interconnects measured were designed as coupon structures about 4.25" long. Ten (10) interconnects on the board were measured. The Differential DUT utilized for the Reproducibility test was a 18" x 24" panel with 4-5" traces.

Assessment Procedure Description

Accuracy

Steps

1) The CI1000 system was verified against the Airline. Several measurements were taken against the Airline to ensure that the system is reporting the correct impedance of the DUT (in this case the airline impedance of 50.02 ohms).

2) Sixteen (16) measurement were taken on each of the ten (10) interconnects. The boards were re-aligned after each set of 16 measurements were made. All measurements were made within a short period of time.
3) The average value of each measured interconnect was assigned as the expected absolute value of interconnect.
4) A simple assessment of the Technical Accuracy was made based solely on the variance of each interconnect from this assigned "expected absolute value".

Repeatability

1) The CI1000 system was verified against the Airline. Several measurements were taken against the Airline to ensure that the system is reporting the correct impedance of the DUT (in this case the airline impedance of 50.02 ohms).
2) Fourteen (14) additional measurements were taken on each of the ten (10) interconnects [for a total of thirty-(30) measurements on each interconnect]. The boards were re-aligned after each set of measurements were made. All measurements were made within a short period of time and within the same day as the previous 16 sets of measurements.

Reproducibility

1) The CI1000 system was verified against the Airline. Several measurements were taken against the Airline to ensure that the system is reporting the correct impedance of the DUT (in this case the airline impedance of 50.02 ohms).
2) Three operators were used over three days.
3) Each operator took three (3) measurements on each of the ten (10) interconnects each day over three (3) days.]. The boards were re-aligned after each set of measurements were made. All measurements were made within a short period of time within each of 3 days.

Precision-to-Tolerance Ratio (P/T)

The P/T ratio is the percentage of specification window that is lost due to measurement error. It is calculated as follows:

$P/T = 100\% * (6 * \sigma) / (\text{Upper Specification Limit} - \text{Lower Specification Limit})$

For the purposes of this study a specification limit of +/- 10% is utilized for all parameters. Smaller tolerance windows will lead to higher P/Ts.

The smaller the value of P/T the more capable is the measurement system. The greater the value of P/T the larger the reduction of the manufacturing process tolerance (i.e., +/- 10% on impedance) which occurs *before* the manufacturing even begins!

Assessment Results – Single-end Impedance

Accuracy

Single-ended Impedance

DUT	Expected Value	Std Dev
1	58.34	0.048
2	55.38	0.035
3	58.99	0.029
4	58.92	0.033
5	49.16	0.035
6	59.69	0.044
7	55.68	0.040
8	58.90	0.039
9	59.15	0.049
10	48.18	0.036

Largest Std Dev: 0.049 Ohms
Result: Pass, All measurements are Technically Accurate

Repeatability

Single-ended Impedance
Largest Std Dev: 0.05 Ohms
Precision vs Tolerance (P/T): 3.05%

Result: Pass, P/T is lower than 12%

Reproducibility

Single-ended Impedance
Largest Std Dev: 0.05 Ohms
Precision vs Tolerance (P/T): 2.65%

Result: Pass, P/T is lower than 20%

Assessment Results – Differential Impedance

Accuracy

Differential Impedance

DUT	Expected Value	Std Dev
1	86.31	0.099
2	85.56	0.126
3	84.93	0.111
4	84.91	0.077
5	85.65	0.067
6	87.60	0.055
7	86.84	0.100
8	86.22	0.094
9	86.47	0.092
10	86.82	0.092

Largest Std Dev: 0.126 Ohms
Result: Pass, All measurements are Technically Accurate

Repeatability

Differential Impedance
Largest Std Dev: 0.110 Ohms
Precision vs Tolerance (P/T): 3.77%

Result: Pass, P/T is lower than 12%

Reproducibility

Differential Impedance
Largest Std Dev: 0.28 Ohms
Precision vs Tolerance (P/T): 9.19%

Result: Pass, P/T is lower than 20%

Assessment Results – Single-end Propagation Delay

Accuracy

Single-ended Prop Delay

DUT	Expected Value	Std Dev
1	2049.59	2.678
2	2105.13	3.442
3	2017.84	2.521
4	2026.72	2.394
5	1938.63	3.433
6	2047.09	2.245
7	2104.19	2.664
8	2017.72	1.807
9	2032.44	1.797
10	1938.91	2.847

Largest Std Dev: 3.44 Psecs
Result: Pass, All measurements are Technically Accurate

Repeatability

Single-ended Prop Delay
Largest Std Dev: 4.44 Psecs
Precision vs Tolerance (P/T): 6.88%

Result: Pass, P/T is lower than 12%

Reproducibility

Single-ended Prop Delay
Largest Std Dev: 3.79 Psecs
Precision vs Tolerance (P/T): 5.61%

Result: Pass, P/T is lower than 20%

Assessment Results – Differential Propagation Delay

Accuracy

Differential Prop Delay

Special Note: DUT1-5 was CH1 of five interconnect differential pairs. DUT6-10 was CH2 of the same five interconnect differential pairs.

DUT	Expected Value	Std Dev
1	721.88	1.384
2	719.06	1.590
3	716.34	1.457
4	721.72	1.291
5	722.81	1.750
6	718.00	1.683
7	718.97	1.176
8	721.63	1.737
9	719.56	1.548
10	716.38	1.245

Largest Std Dev: 1.75 Psecs
Result: Pass, All measurements are Technically Accurate

Repeatability

Differential Prop Delay

Largest Std Dev: 2.78 Psecs
Precision vs Tolerance (P/T): 10.37%

Result: Pass, P/T is lower than 12%

Reproducibility

Differential Prop Delay

Largest Std Dev: 3.98 Psecs
Precision vs Tolerance (P/T): 17.54%

Result: Pass, P/T is lower than 20%