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Mitigating the Effect of Connector Mating
and Normal Forces in Signal Integrity

Juan Aguirre

Overview

- Normal forces on a single-pin and multi-pin geometries
- Force vs Deflection graphs, simulation and measurements
- Interposer example (Full vs Partially Mated)
- Cable assembly example (Full vs Partially Mated)
- Presented solutions, Documentation & Mitigation

Normal Forces on Single-Pin Geometries

Material	Elastic Modulus (MPa)	Poissons Ratio	Yield Strength (MPa)	Tangent Modulus (MPa)	S-S curve
Cu	15900000	0.34	40611	1.66E+05	

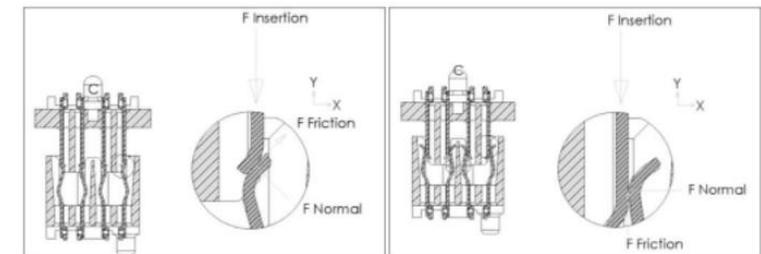
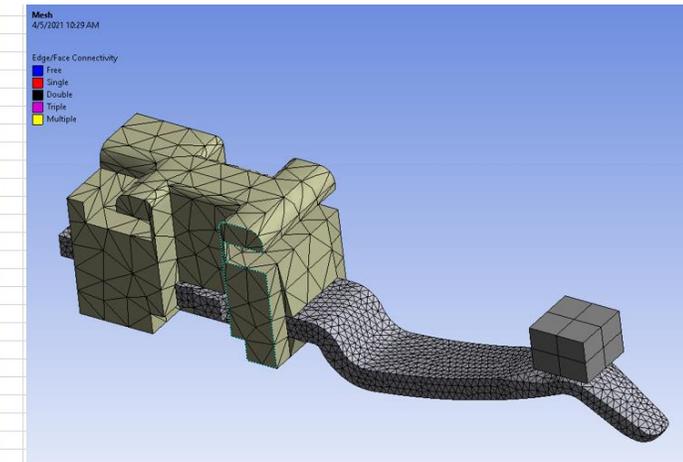
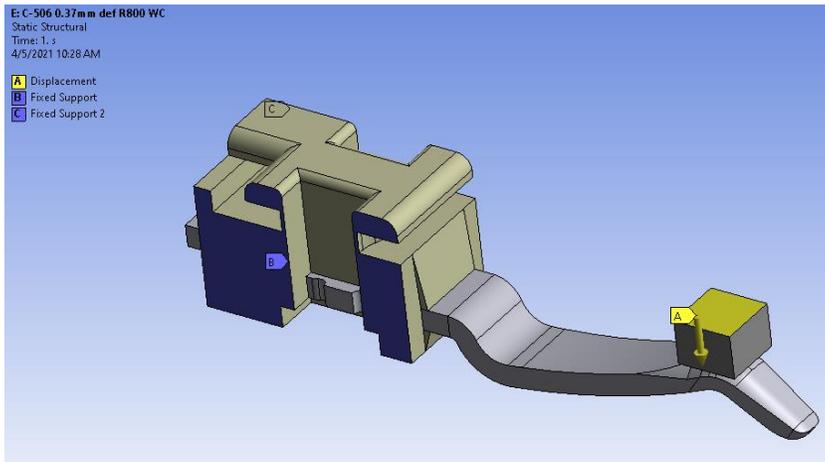
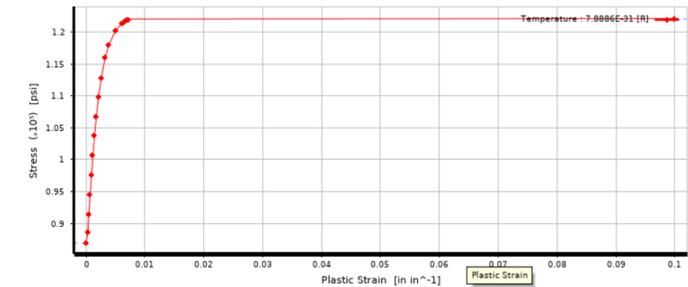
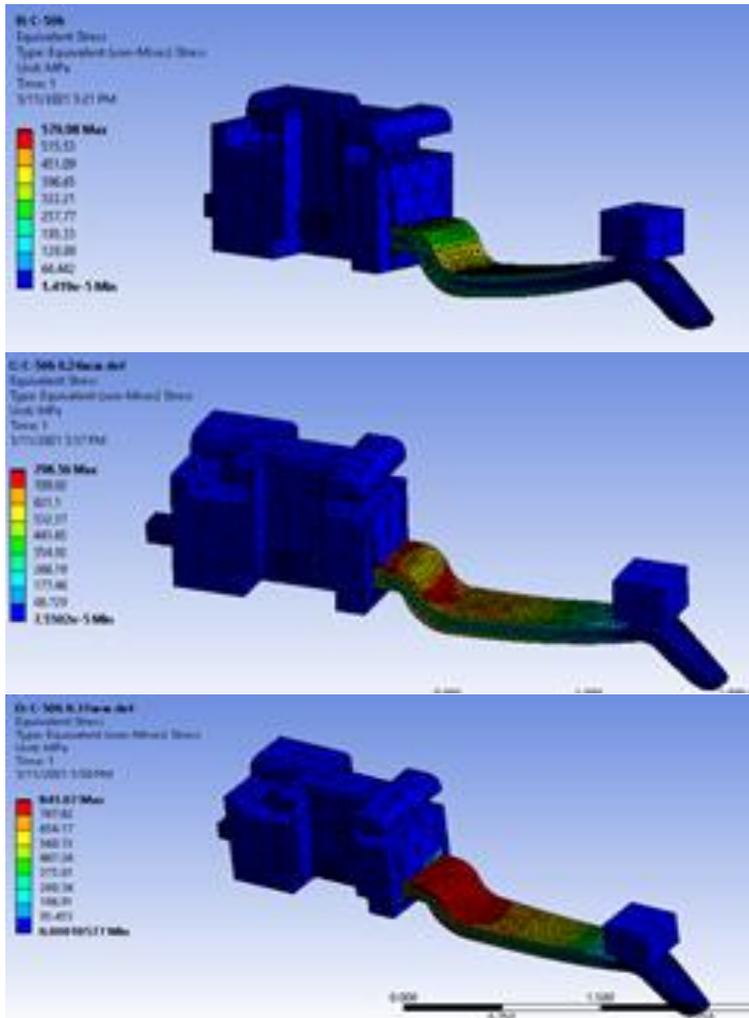


Figure 1 – Spreading Stage

Figure 2 – Sliding Stage

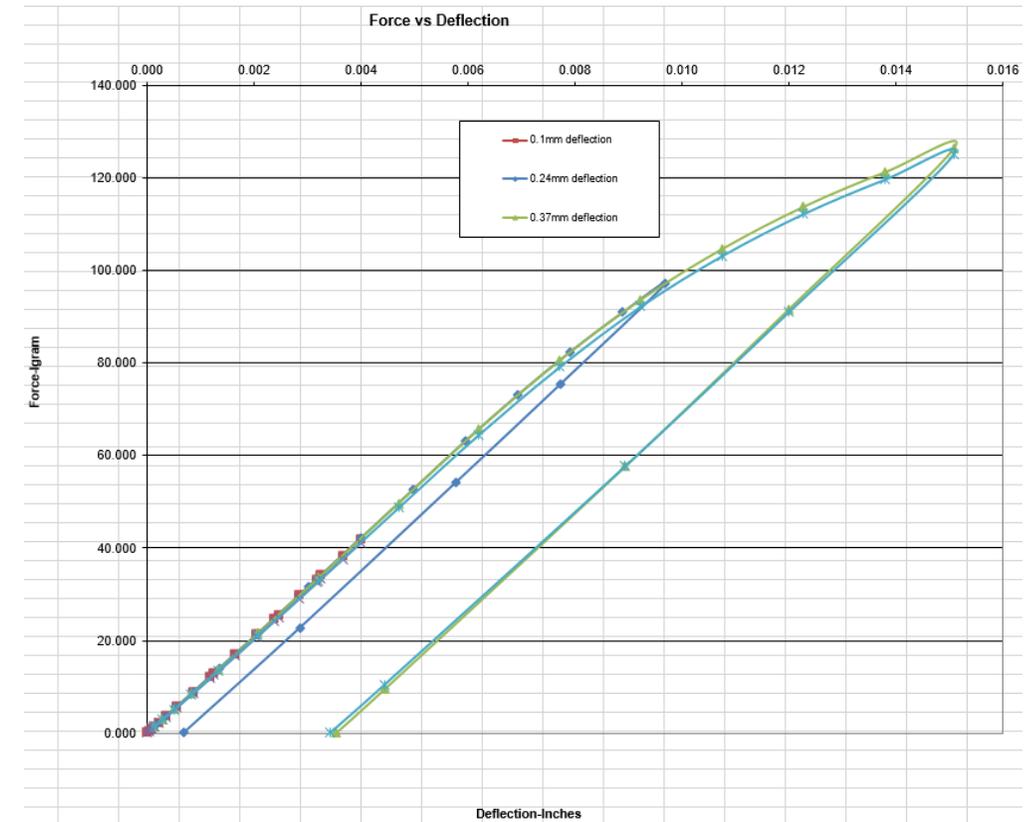
Force and Deflection on Single-Pin Geometries



Sample Case	Force (grams)	Deflection value
1	42	0.10 mm
2	96	0.24 mm
3	126	0.37 mm

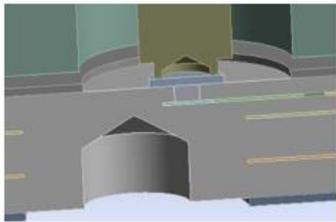
Force vs Deflection Graphs

0.10mm deflection		0.24mm deflection		0.37mm deflection	
displacement (in)	Force (g)	displacement (in)	Force (g)	displacement (in)	Force (g)
0.0000	0.4	9.00E-05	9.08E-01	1.41E-04	1.42E+00
0.0001	0.7	1.84E-04	1.86E+00	2.87E-04	2.90E+00
0.0001	1.3	3.26E-04	3.30E+00	5.05E-04	5.13E+00
0.0002	2.2	5.38E-04	5.48E+00	8.36E-04	8.55E+00
0.0004	3.6	8.61E-04	8.81E+00	1.33E-03	1.37E+01
0.0006	5.6	1.35E-03	1.39E+01	2.08E-03	2.16E+01
0.0009	8.8	2.07E-03	2.15E+01	3.21E-03	3.36E+01
0.0013	12.9	3.03E-03	3.17E+01	4.70E-03	49.65852
0.0017	17.1	4.00E-03	4.21E+01	6.21E-03	65.72558
0.0021	21.3	4.97E-03	52.5732	7.71E-03	80.4715
0.0025	25.5	5.95E-03	63.0288	9.23E-03	93.58756
0.0029	29.8	6.92E-03	72.9487	1.08E-02	104.53804
0.0033	34.1	7.90E-03	82.2693	1.23E-02	113.67252
0.0037	38.3	8.89E-03	90.8636	1.38E-02	121.18622
0.0040	41.9	9.70E-03	97.1378	1.51E-02	126.29826
0.0032	33.3	7.72E-03	75.3413	1.20E-02	91.48554
0.0024	24.7	5.77E-03	54.1259	8.94E-03	57.62168
0.0012	12.1	2.86E-03	2.27E+01	4.44E-03	9.43E+00
0.0000	0.0	6.87E-04	8.06E-11	3.54E-03	-1.66E-11

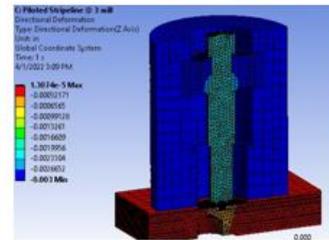


Force, Deflection & Displacement

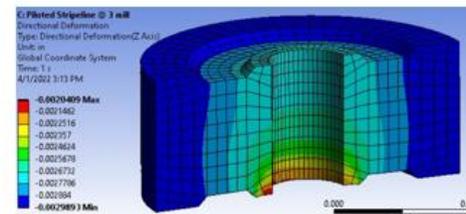
Original pilot, .003" gap



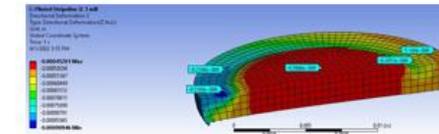
System displacement (in)



Bead displacement (in)

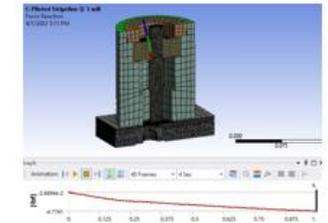


Pad displacement (in)

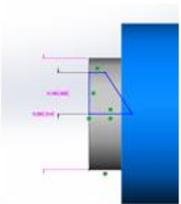


Reaction Force (lbf)

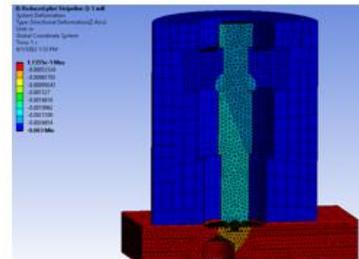
9.54 (double graph values for symmetry)



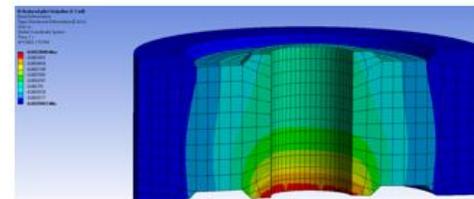
Reduced pilot, .003" gap



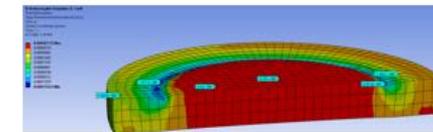
System displacement (in)



Bead displacement (in)

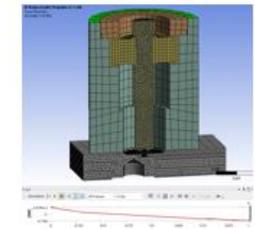


Pad displacement (in)



Reaction Force (lbf)

8.26 (double graph values for symmetry)



Force & Deflection % on Multiple Pins

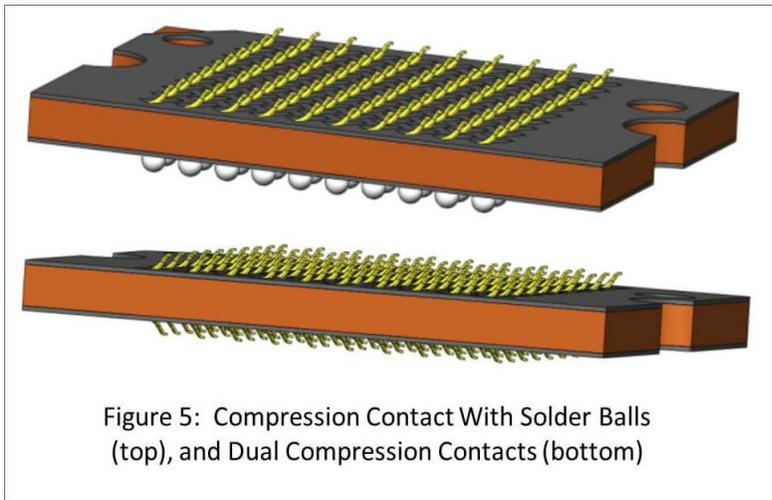


Figure 5: Compression Contact With Solder Balls (top), and Dual Compression Contacts (bottom)

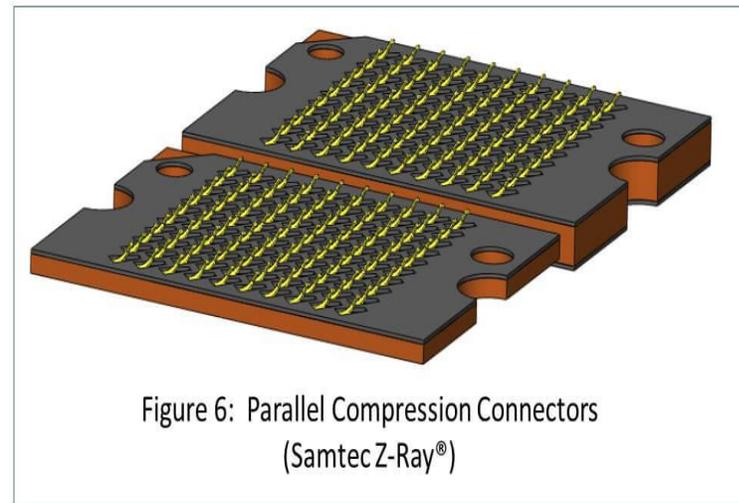


Figure 6: Parallel Compression Connectors (Samtec Z-Ray®)

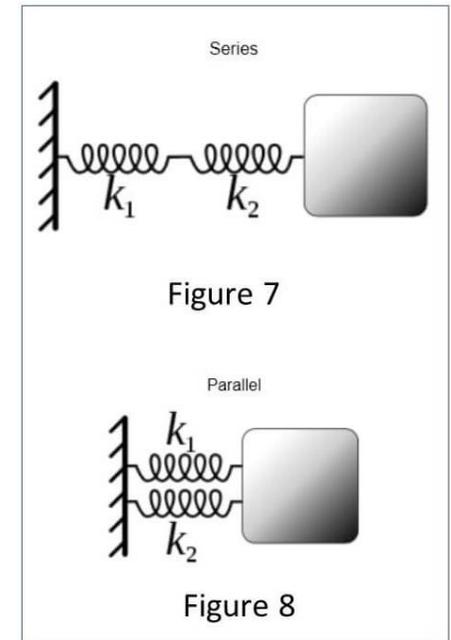


Figure 7

Figure 8

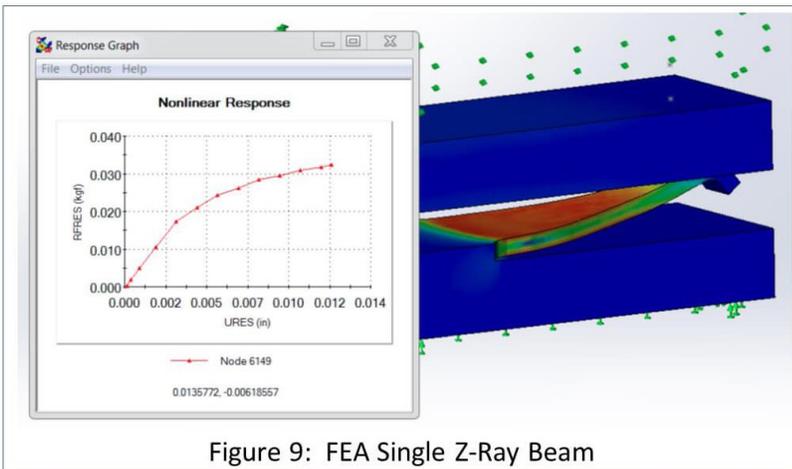


Figure 9: FEA Single Z-Ray Beam

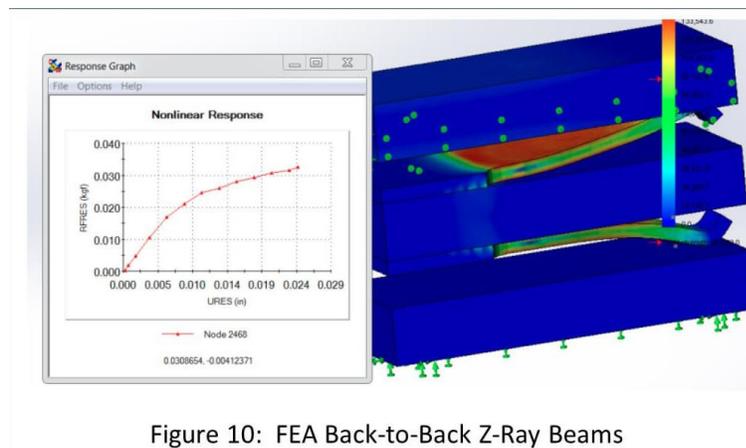
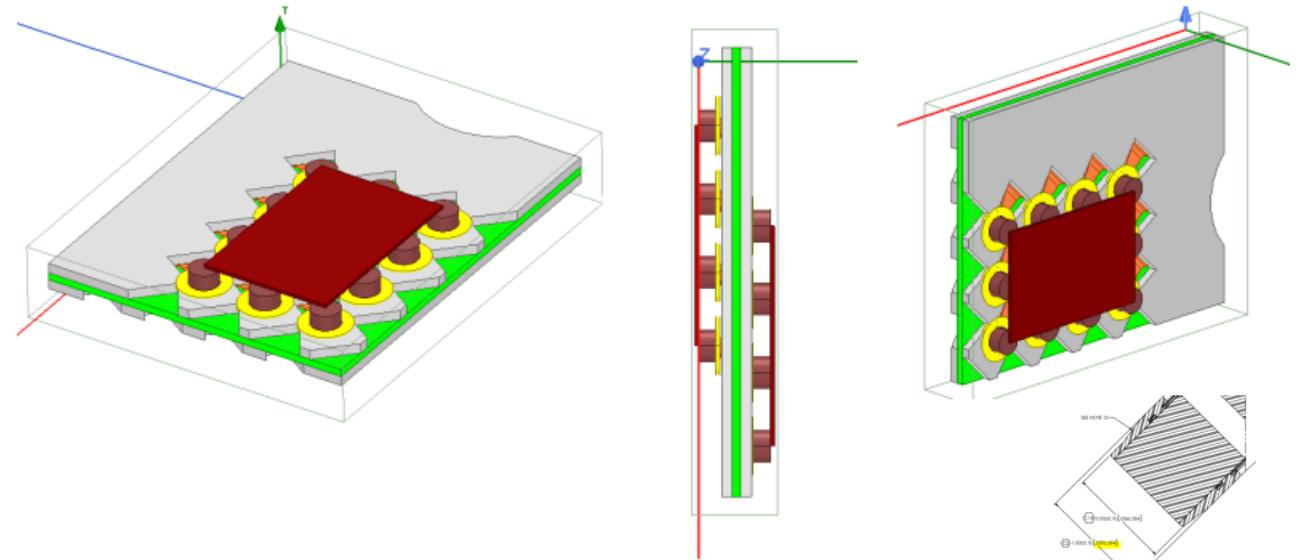


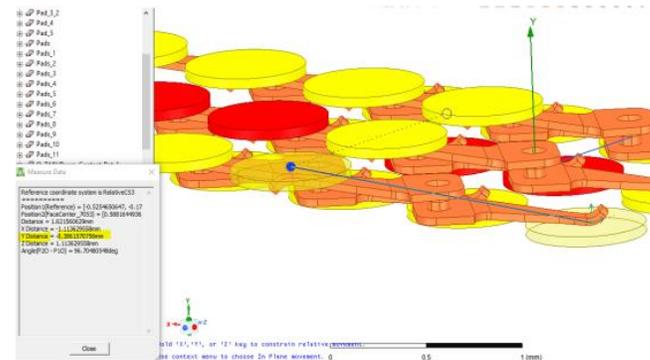
Figure 10: FEA Back-to-Back Z-Ray Beams

Force & Deflection % on Multiple Pins

Base model parameter fully mated distance Base = 0.3861 mm inner face pad vs 0.39 dwg
3 deflected models references by % where each unit base model is already deflected by 1% to ensure contact



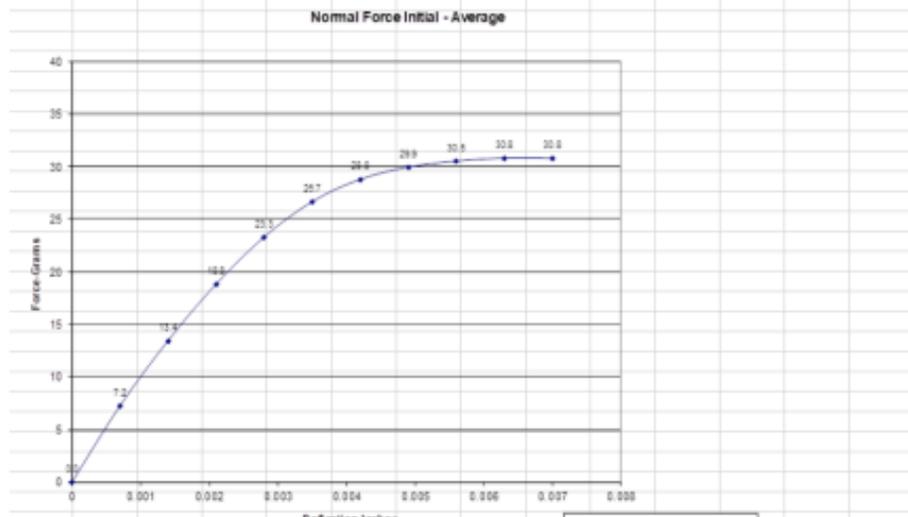
Case #	Deflection %	Value in mm
1	4%	0.0154 mm
2	8%	0.0308 mm
3	12%	0.0463 mm



Force vs Deflection Graphs Measured

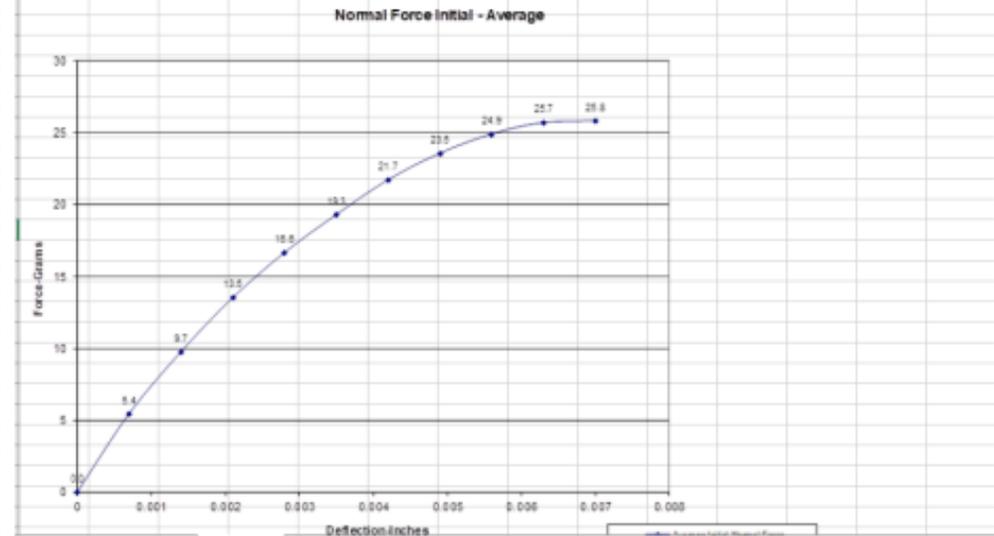
Initial	Deflections in inches Forces in Grams											Defl at 0g
	0.0007	0.0014	0.0021	0.0028	0.0035	0.0042	0.0049	0.0056	0.0063	0.007	SET	
Averages	7.24	13.44	18.82	23.3	26.66	28.78	29.94	30.52	30.8	30.78	0.0024	0
Min	4	9.3	14	18	21.9	25.3	27.7	29.3	29.2	28.8	0.0017	
Max	10.1	18	24.2	29.5	31.8	32.9	33.2	33.2	32.9	32.4	0.0031	
St. Dev	2.214	3.227	3.789	4.291	3.706	2.742	2.034	1.69	1.56	1.736	0.0006	
Count	5	5	5	5	5	5	5	5	5	5	5	

Initial	Deflections in inches, Forces in Grams											SampleID	Pin #
Item #	0.0007	0.0014	0.0021	0.0028	0.0035	0.0042	0.0049	0.0056	0.0063	0.007	SET		
1	8.1	14.7	20.3	24.9	28.3	29.2	29.4	29.4	29.4	28.8	0.0028	1	1
2	10.1	18	24.2	29.5	31.8	32.9	33.2	33.2	32.9	32.4	0.0031	2	13
3	6.8	12	17.1	21.2	24.9	27.9	30.2	31.2	31.7	32	0.002	3	1
4	7.2	13.2	18.5	22.9	26.4	28.6	29.2	29.3	29	29	0.0024	4	26
5	4	9.3	14	18	21.9	25.3	27.7	29.5	30.8	31.7	0.0017	5	13

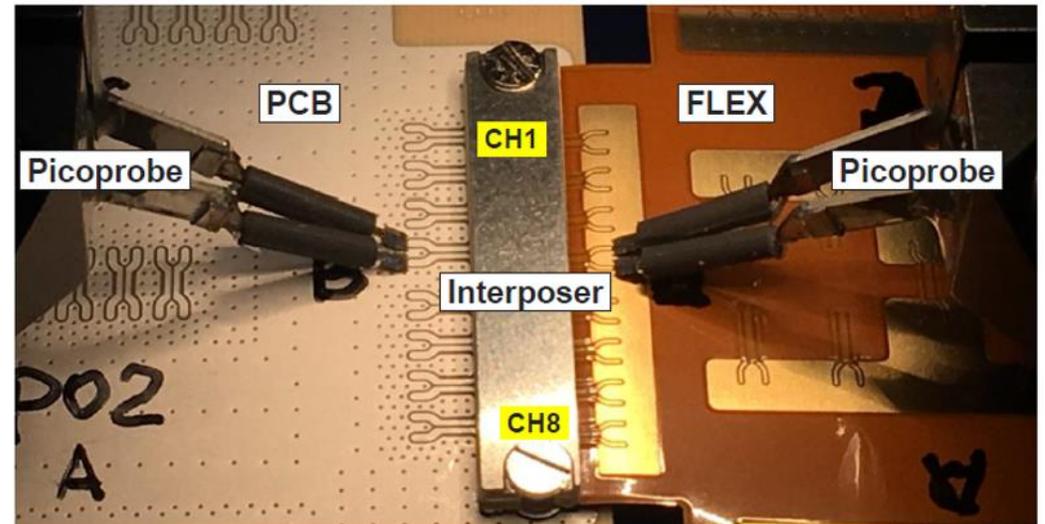
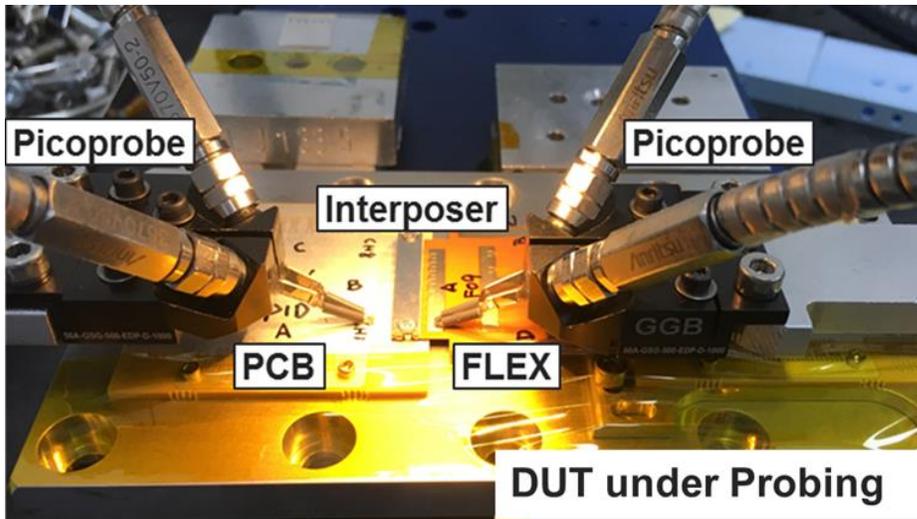


Initial	Deflections in inches Forces in Grams											Defl at 0g
	0.0007	0.0014	0.0021	0.0028	0.0035	0.0042	0.0049	0.0056	0.0063	0.007	SET	
Averages	5.44	9.74	13.5	16.64	19.28	21.7	23.54	24.88	25.68	25.8	0.0017	0
Min	4.8	8.8	12.6	15.4	17.9	20.2	22	23.5	24.4	24.8	0.0011	
Max	6.1	10.9	14.8	18	20.7	23.2	25	26	27.6	28	0.0025	
St. Dev	0.619	1.021	1.068	1.242	1.285	1.364	1.356	1.236	1.322	1.317	0.0005	
Count	5	5	5	5	5	5	5	5	5	5	5	

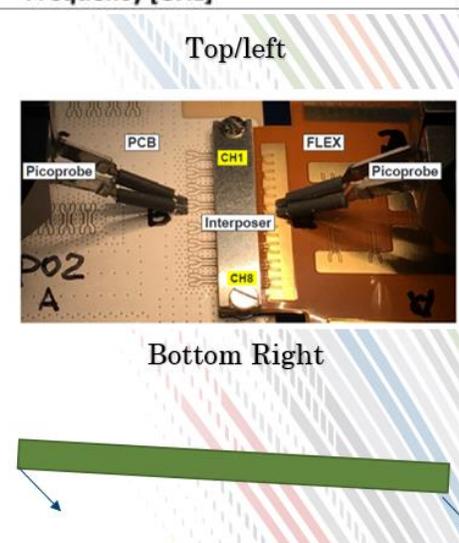
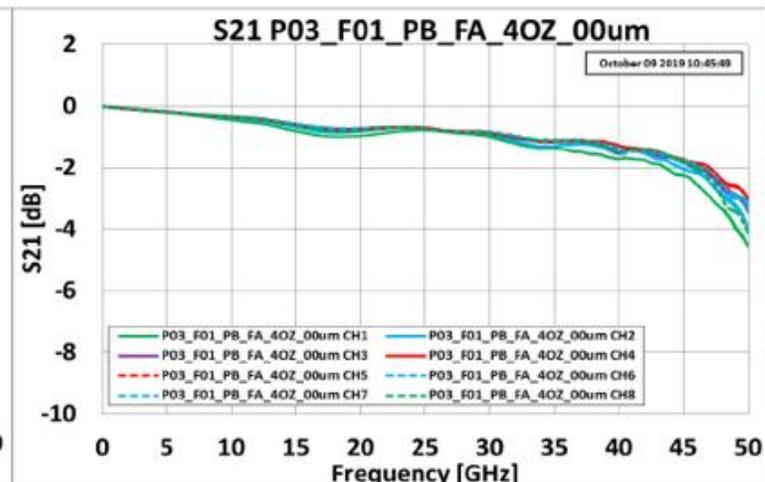
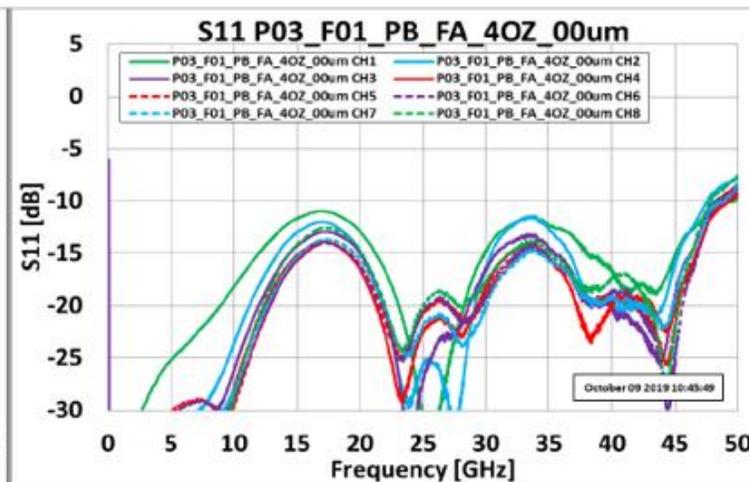
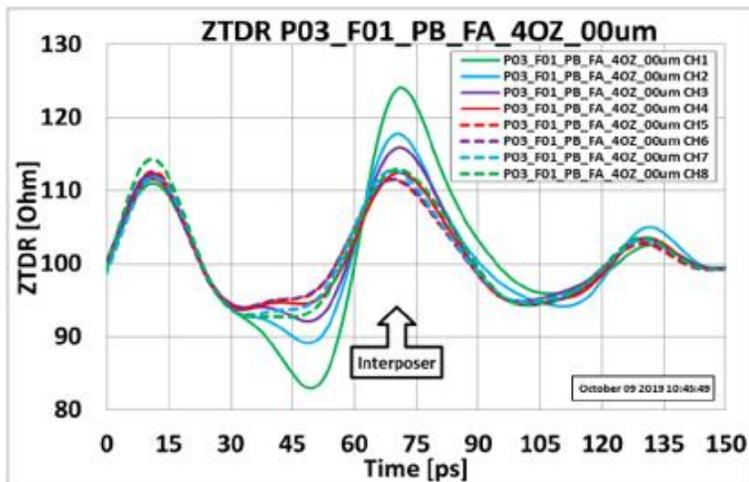
Initial	Deflections in inches, Forces in Grams											SampleID	Pin #
Item #	0.0007	0.0014	0.0021	0.0028	0.0035	0.0042	0.0049	0.0056	0.0063	0.007	SET		
1	5.2	9.1	12.6	15.6	18.2	20.4	22.2	23.6	24.5	24.8	0.0013	1	1
2	6.1	10.8	14.5	17.9	20.5	22.8	24.4	25.4	25.7	25.5	0.0017	2	13
3	4.8	8.8	12.6	15.4	17.9	20.2	22	23.5	24.4	24.8	0.0011	3	1
4	6.1	10.9	14.8	18	20.7	23.2	25	25.9	26.2	25.9	0.0018	4	26
5	5	9.1	13	16.3	19.1	21.9	24.1	26	27.6	28	0.0025	5	13



Interposer Example



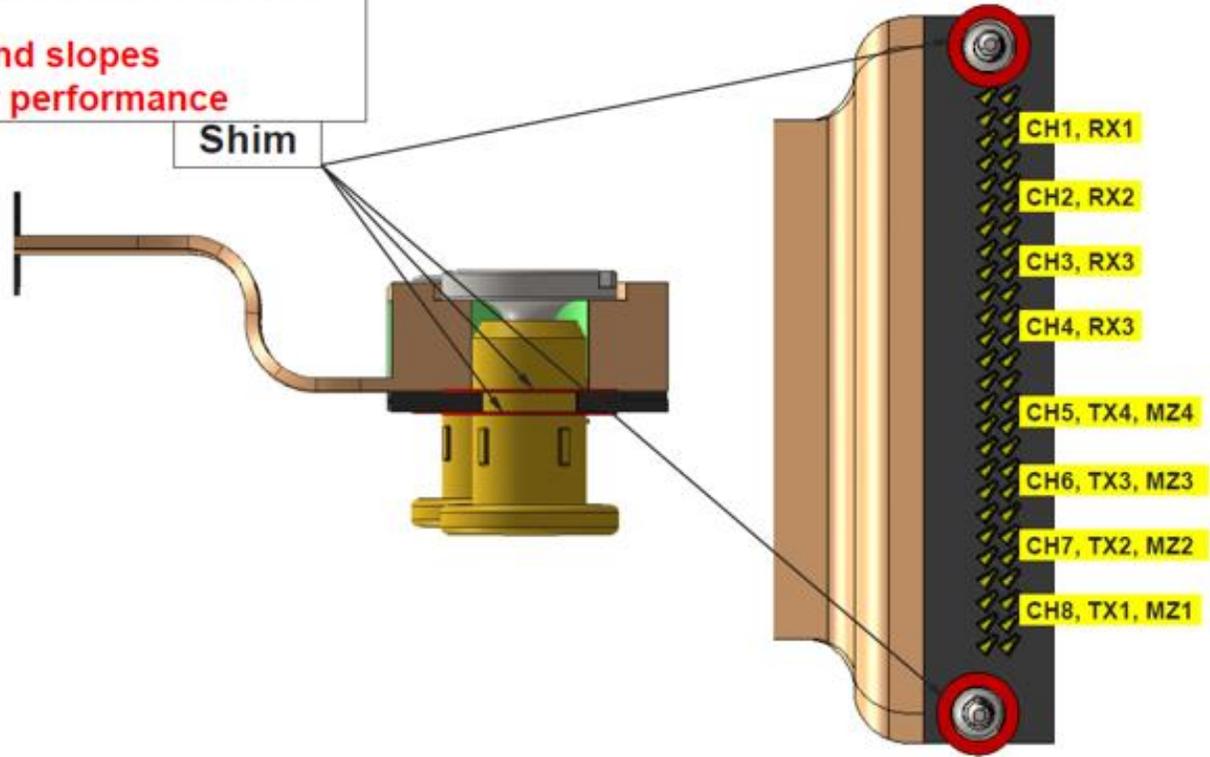
Interposer Example Measurements (TDR, S11, S21)



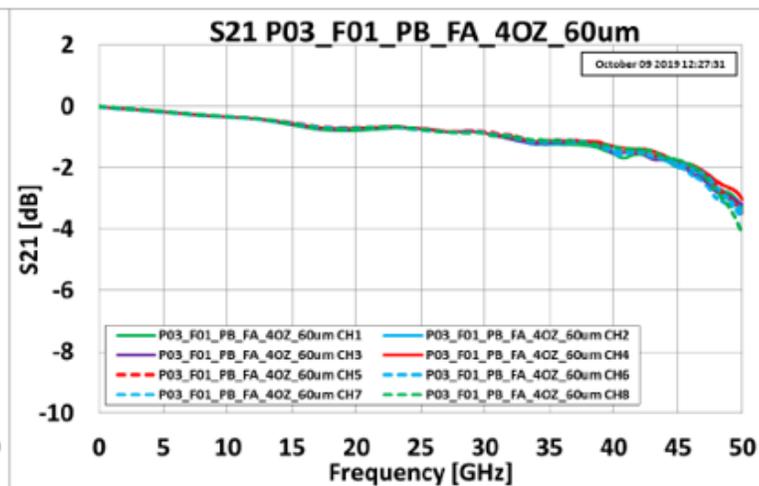
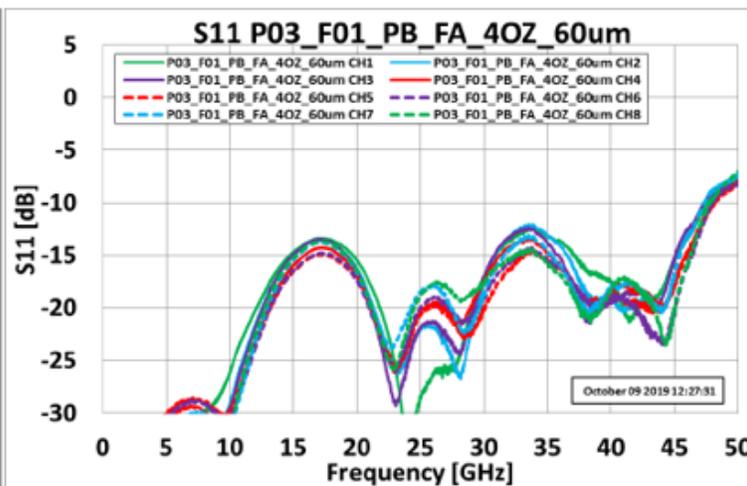
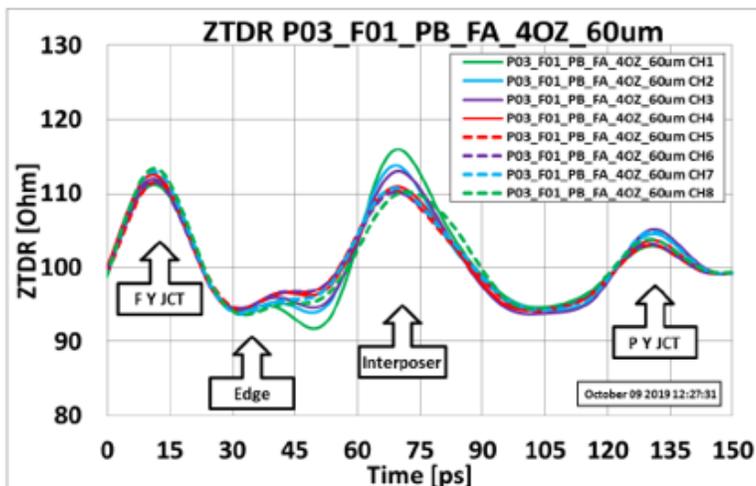
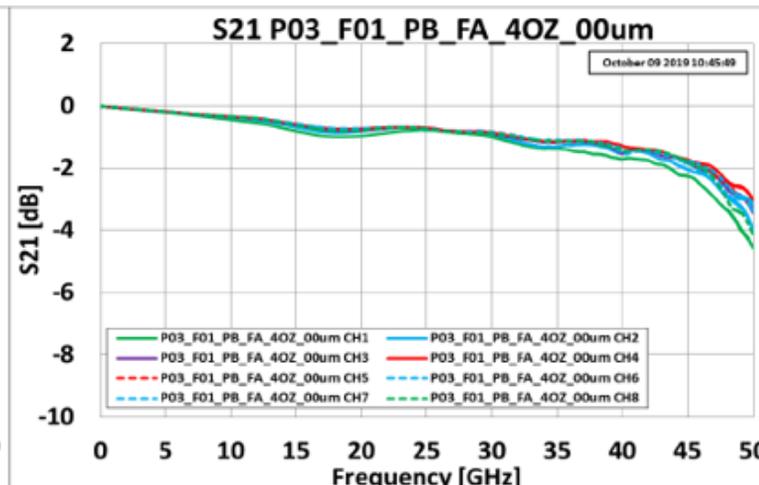
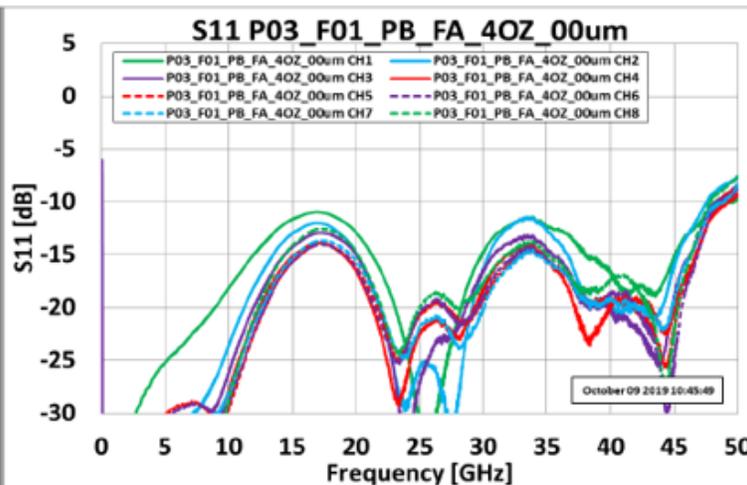
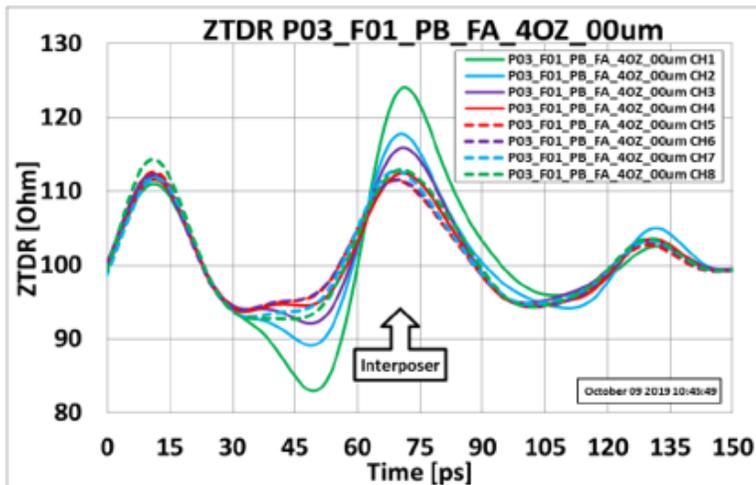
Adding Shim

- With 60um shim,
- Impedance would get better matched at interposer
 - S11 would be improved
 - S21 would have better ripples and slopes
 - All 4 channels would get similar performance

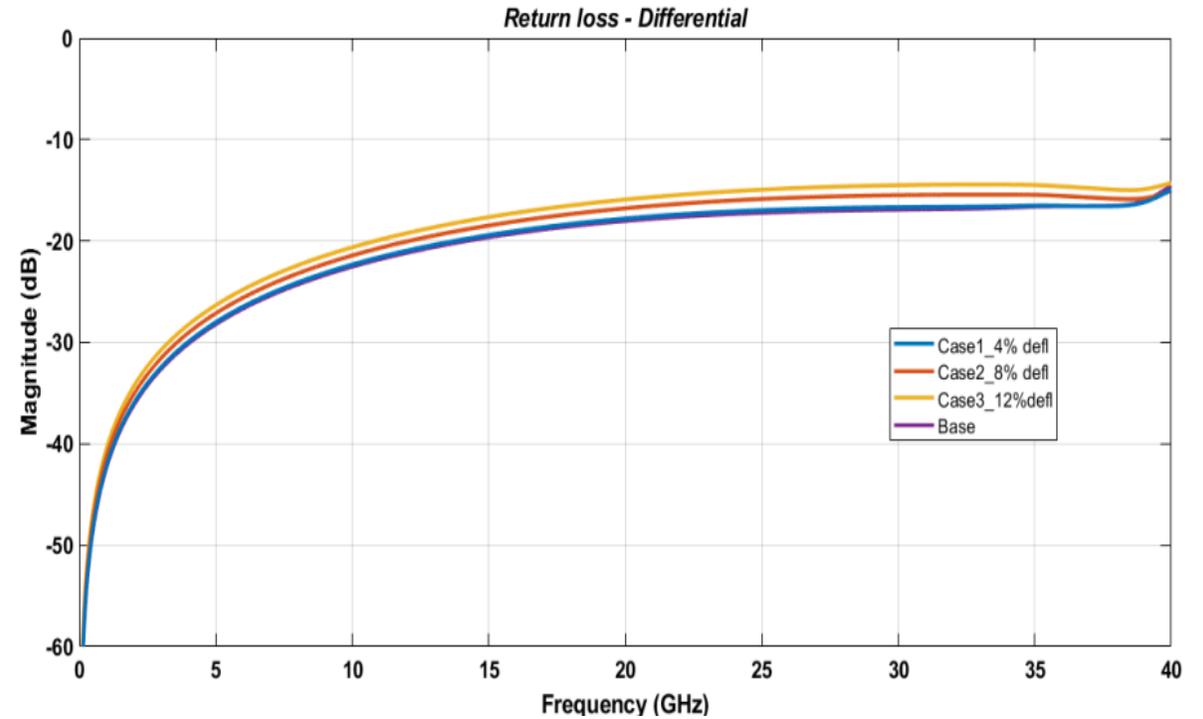
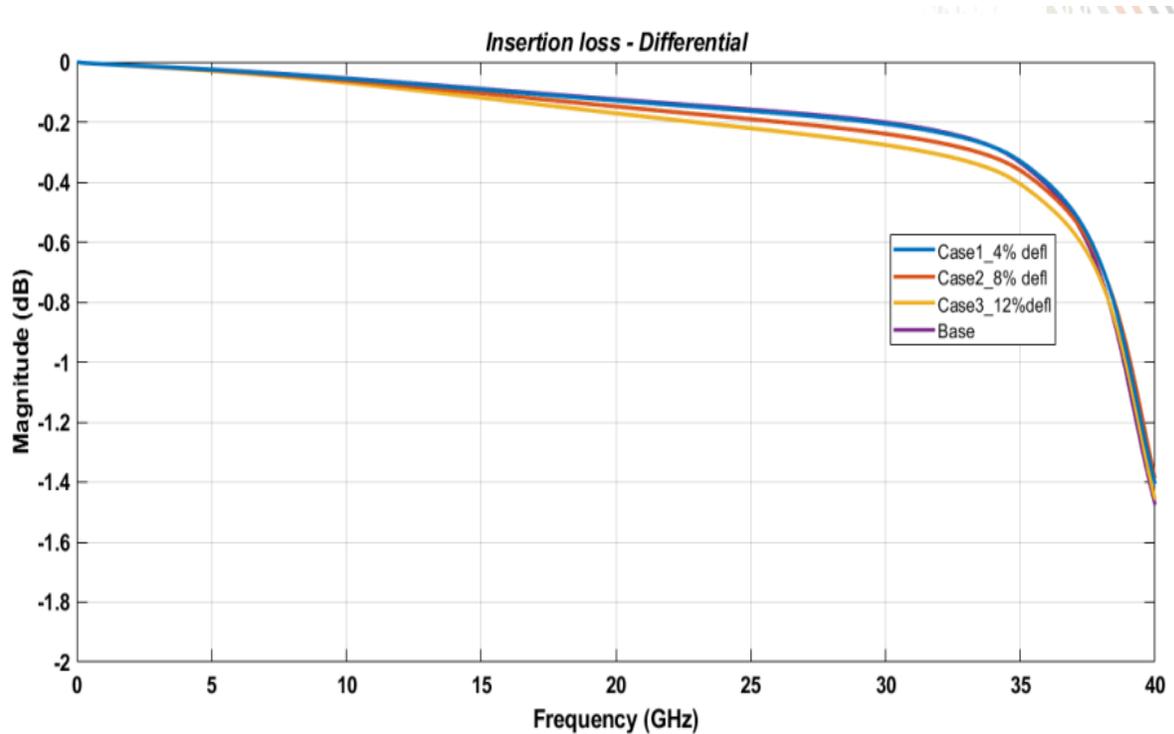
Thickness: 60.00um
ID: 2.00mm
OD: 3.00mm



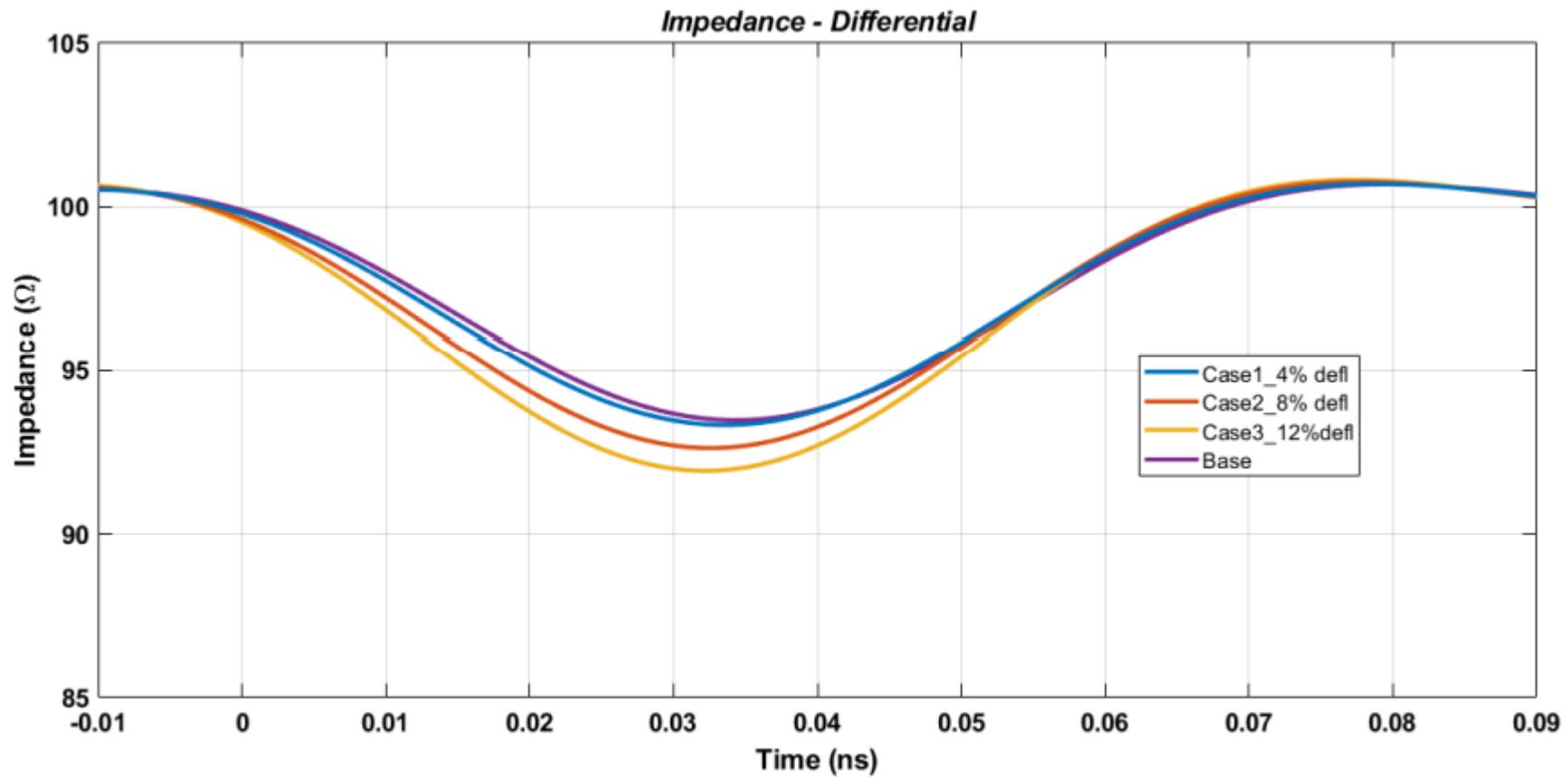
Measurement Comparison With & Without Shim



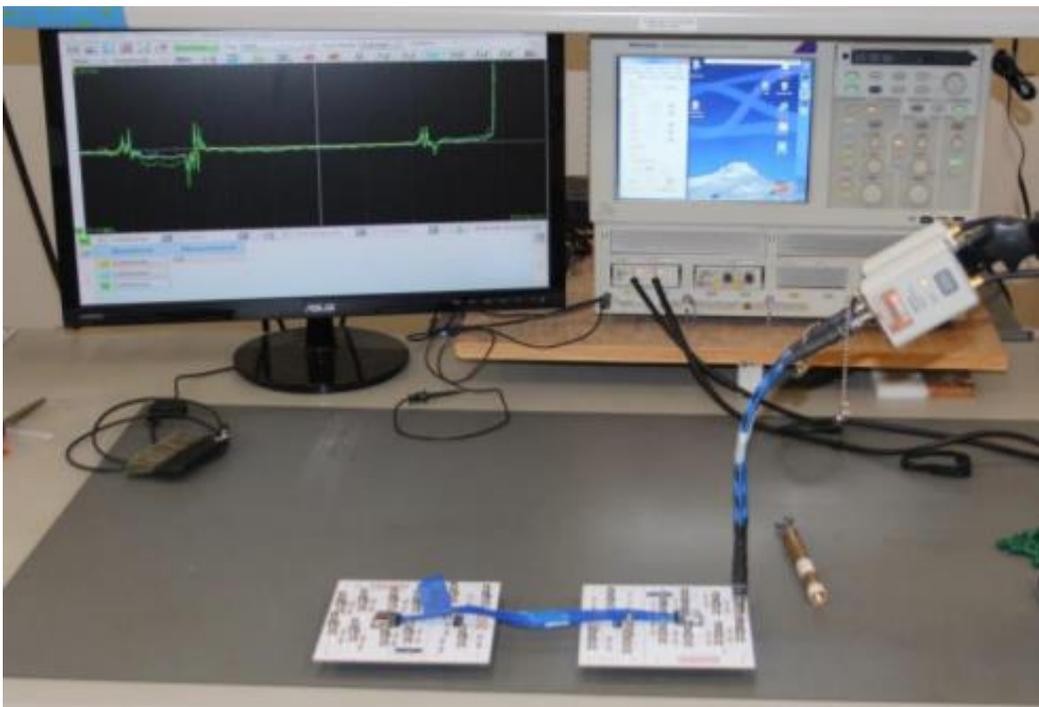
Added Deflection % on Contacts Results



Added Deflection % on Contacts Results



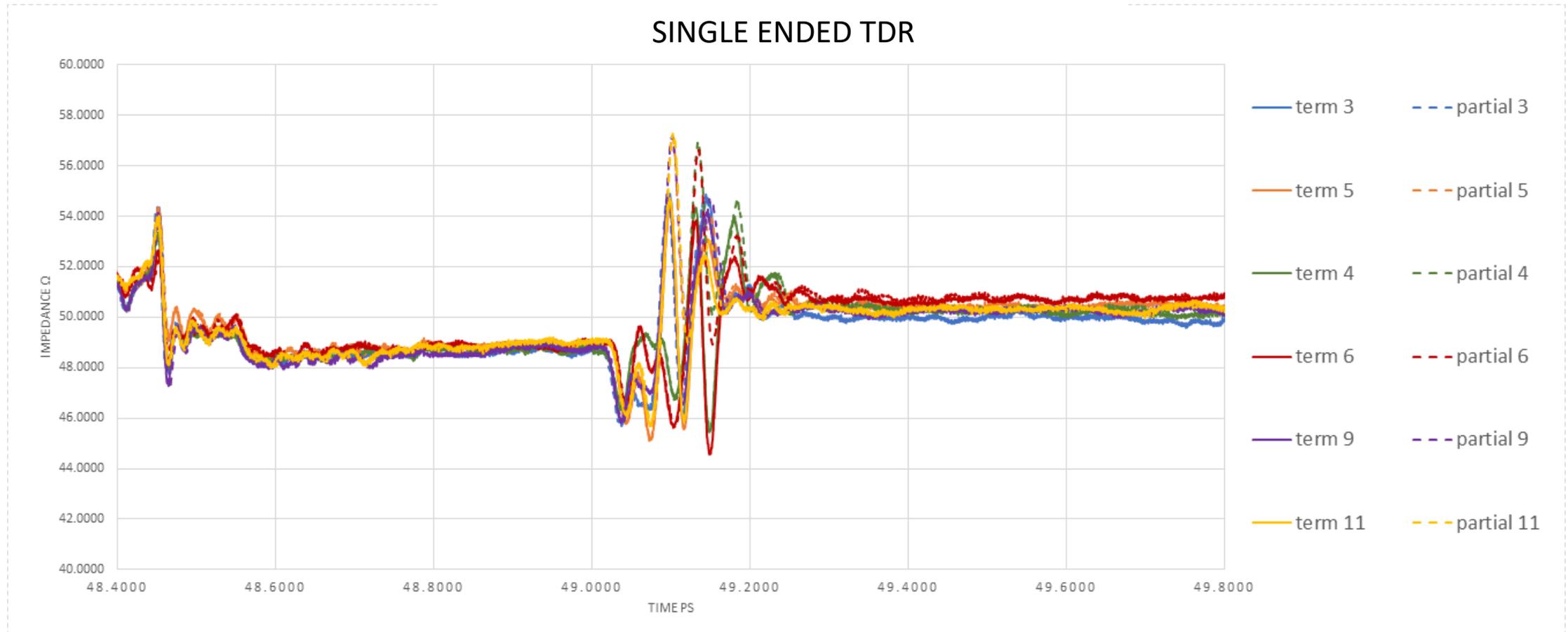
Cable Assembly Example



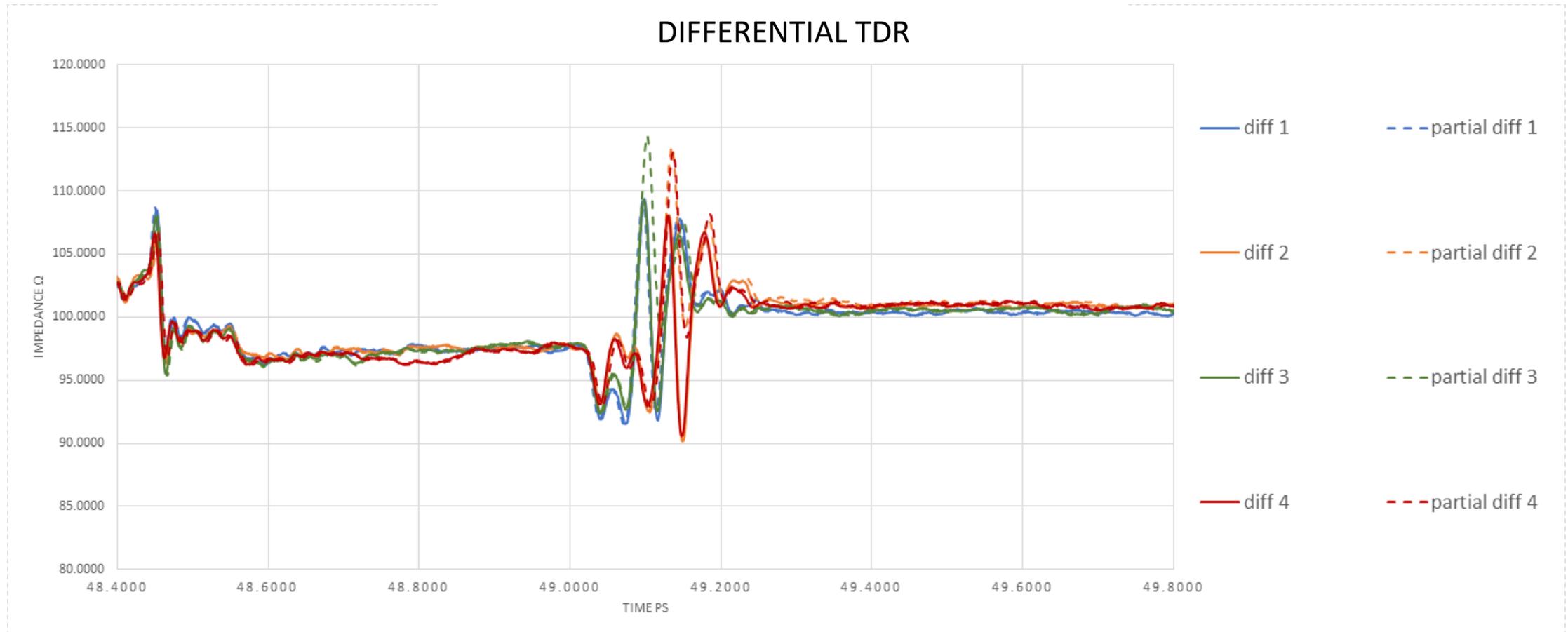
SAMPLE TEST PIN MAPPING

Odd -1 GND		Even-2 GND	
3 - terminal 3 / SE1	Diff 1	4- terminal 4 / SE3	Diff 2
5- terminal 5 / SE2		6- terminal 6 / SE4	
7 GND		8 GND	
9- terminal 9 / SE5	Diff 3	10- terminal 10 / SE7	Diff 4
11 terminal 11 / SE6		12- terminal 12 / SE8	
13 GND		14GND	

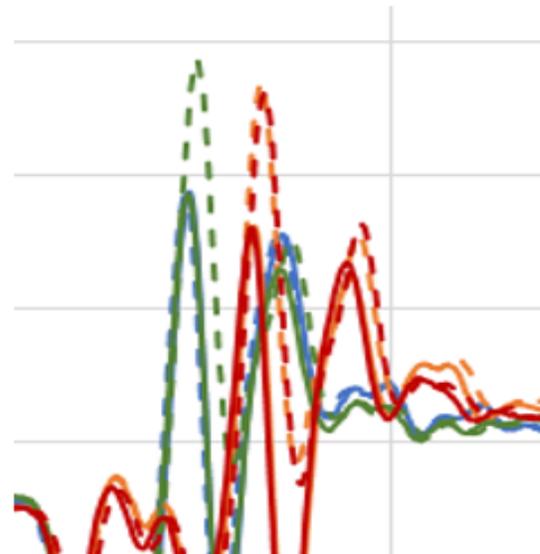
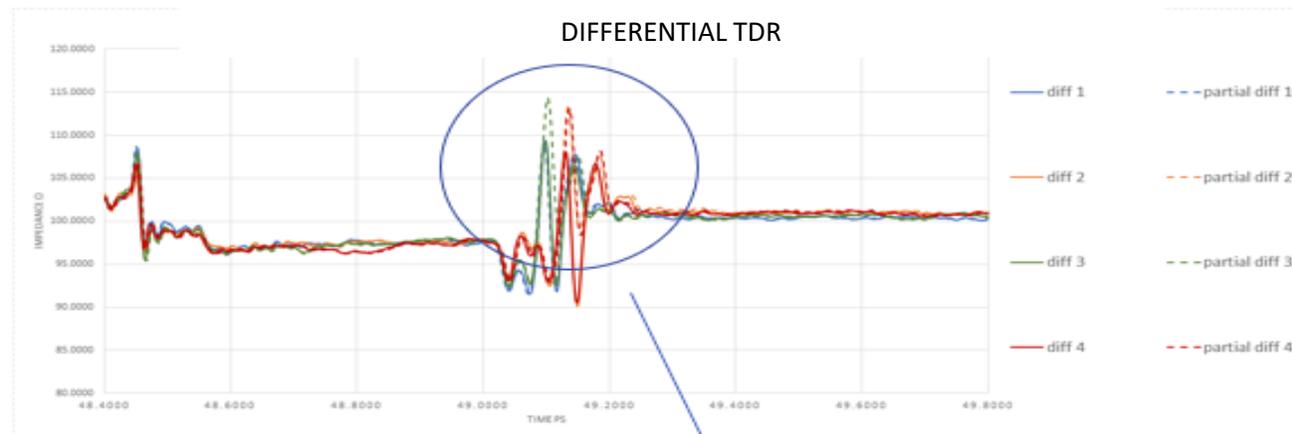
Fully Mated & Partially Mated Results



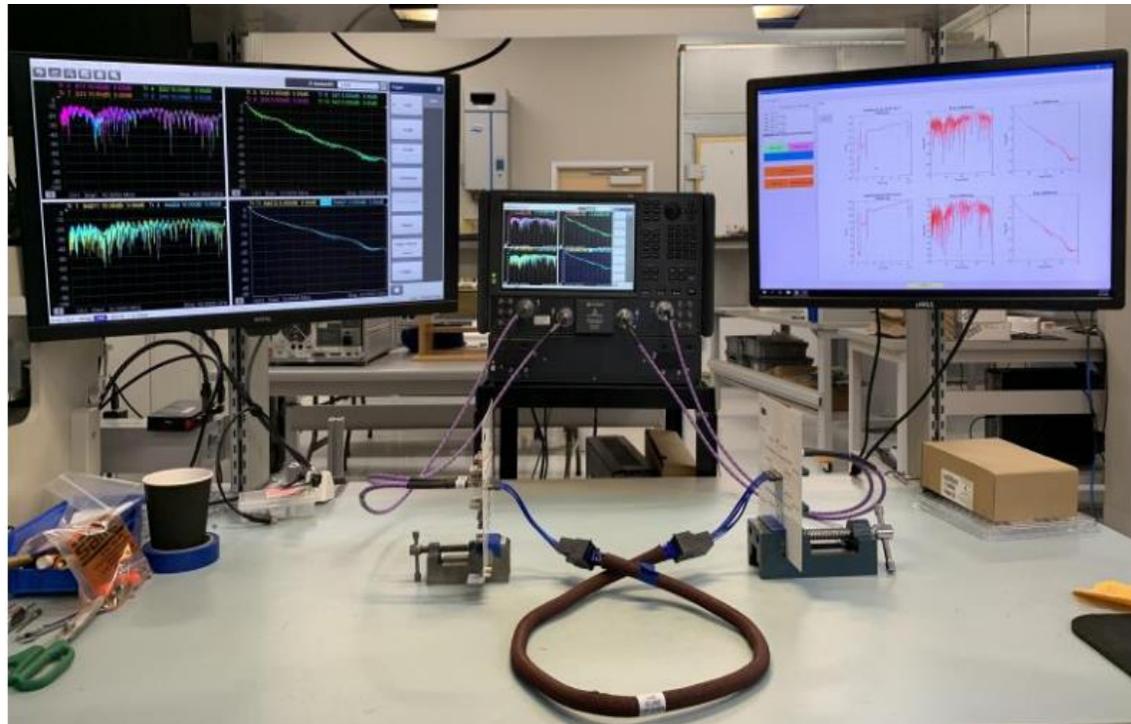
Fully Mated & Partially Mated Results



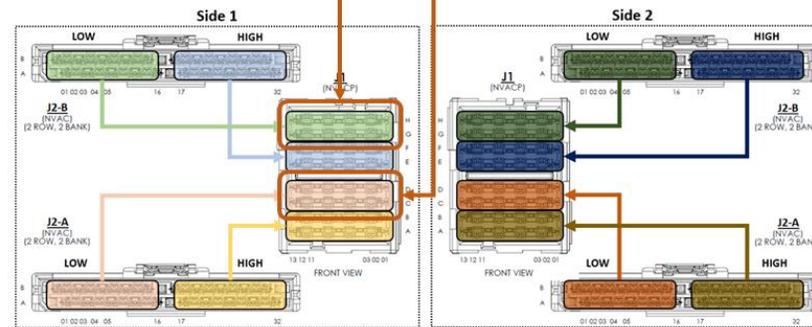
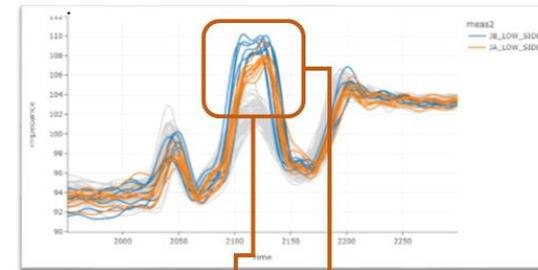
Fully Mated & Partially Mated Results



Cable Assembly Example



De-mate



-1 Pin Mapping (existing cables in lab)

SIDE 1		SIDE 2			
VNA Meas	NVAC1	NVACP-CE1	NVACE-CP2	NVAC2	VNA Meas
Diff Pair	B LOW SIDE1		B LOW SIDE2		Diff Pair
5	A2, A3	D12, D11		A2, A3	13
6	A6, A7	D9, D8		A6, A7	14
7	A10, A11	D6, D5	Row 8 (H)	A10, A11	15
8	A14, A15	D3, D2		A14, A15	16
1	B1, B2	C12, C11		B1, B2	9
2	B4, B5	C9, C8	Row 7 (C)	B4, B5	10
3	B10, B11	C6, C5		B10, B11	11
4	B14, B15	C3, C2		B14, B15	12
Diff Pair	B HIGH SIDE1		B HIGH SIDE2		Diff Pair
5	A18, A19	A12, A11		A18, A19	13
6	A22, A23	A9, A8		A22, A23	14
7	A26, A27	A6, A5	Row 6 (F)	A26, A27	15
8	A30, A31	A3, A2		A30, A31	16
1	B14, B15	B12, B11		B14, B15	9
2	B18, B19	B9, B8	Row 5 (E)	B18, B19	10
3	B22, B23	B6, B5		B22, B23	11
4	B26, B27	B3, B2		B26, B27	12
Diff Pair	A LOW SIDE1		A LOW SIDE2		Diff Pair
5	A2, A3	D12, D11		A2, A3	13
6	A6, A7	D9, D8		A6, A7	14
7	A10, A11	D6, D5	Row 4 (D)	A10, A11	15
8	A14, A15	D3, D2		A14, A15	16
1	B1, B2	C12, C11		B1, B2	9
2	B4, B5	C9, C8	Row 3 (C)	B4, B5	10
3	B10, B11	C6, C5		B10, B11	11
4	B14, B15	C3, C2		B14, B15	12
Diff Pair	A HIGH SIDE1		A HIGH SIDE2		Diff Pair
5	A18, A19	A12, A11		A18, A19	13
6	A22, A23	A9, A8		A22, A23	14
7	A26, A27	A6, A5	Row 2 (B)	A26, A27	15
8	A30, A31	A3, A2		A30, A31	16
1	B14, B15	B12, B11		B14, B15	9
2	B18, B19	B9, B8	Row 1 (A)	B18, B19	10
3	B22, B23	B6, B5		B22, B23	11
4	B26, B27	B3, B2		B26, B27	12

3D SI Models with Proper Deflection

Configure Your Product Using the Options Below

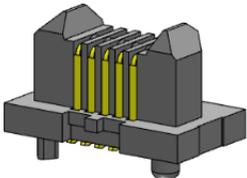
ERM8-005-02.0-L-DV-FR

Part Number	ERM8-005-02.0-L-DV-FR
Series	ERM8
Number of Positions	005
Lead Style	-02.0 = 2mm
Lead Style Note	For EGPS-K-TR combinations leave the zero off the front of the lead style callout
Plating	-L: 10 µ" Light Selective Gold in Contact Area, Matte Tin on Tail
Number of Rows	-DV: Double Vertical
Differential Pair (Hot Swap)	Not Available
Differential Pair with Extended Guide Posts	Not Available
Differential Pair with Extended Guide Post Shield	Not Available
Latches	Not Available
Shield Option	Not Available
Extended Guide Posts	Not Available
Extended Guide Post Shield	Not Available
Polyimide Film Pad	Not Selected
Packaging Option	-FR, Full Reel

Generale CAD

You have currently no CAD models available for download or mail delivery.

3D Dimension SNAP-EDA

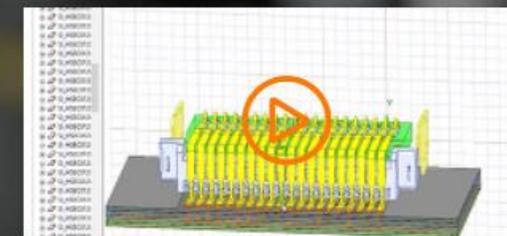


Save your preferred CAD Download type in [your user profile](#).
2D view may not be representative of the configured product. Please see 3D preview or CAD download for actual representation.
Need help choosing your options? [View Catalog Page](#)
Please confirm configuration with the [Series Print](#) before final design in.
For assistance with 3D Models, please contact e3DModels@Samtec.com.
For 3D Models suitable for EM Field Solvers, please contact [Samtec's Signal Integrity Group](#).

Ansys 3D Components from Samtec

Samtec has partnered with Ansys to offer 3D simulation-ready components of some of our most popular interconnect solutions. Ansys HFSS users can now download and import encrypted connector and break out region (BOR) models directly into the Ansys HFSS tool flow. Ansys 3D Components from Samtec simplifies system-level simulation and offers convenient design re-use.

For assistance, e-mail our technical experts at SIG@samtec.com



Samtec & Ansys 3D SI Models

<https://www.samtec.com/lp/si-models>

Recommended Documentation

REVISION A | APF6-APM6 Misalignment Document

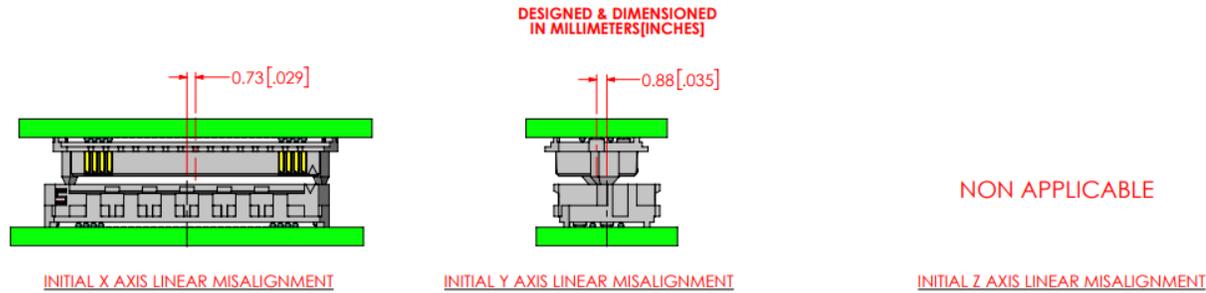


TABLE 1

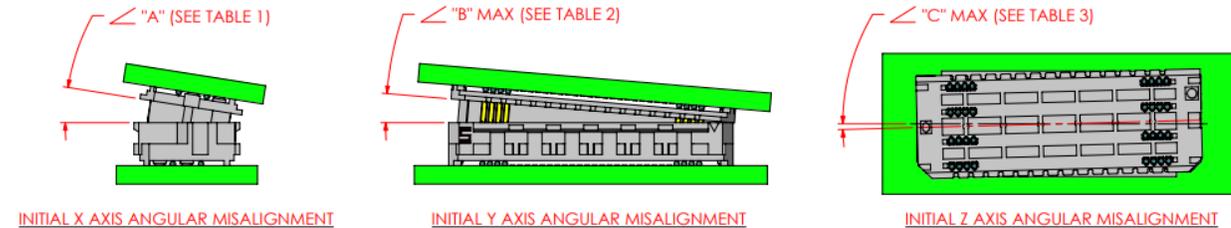
ROW	"A"=DEG
4	9.05
6	5.84
8	4.63
10	3.56
16	2.22

TABLE 2

NO OF POS	"B"=DEG	NO OF POS	"B"=DEG
10	11.97	60	2.37
20	6.88	70	2.00
30	4.82	80	1.71
40	3.63	90	1.49
50	2.88	100	1.31

TABLE 3

NO OF POS	"C"=DEG	NO OF POS	"C"=DEG
10	3.69	60	1.46
20	2.82	70	1.30
30	2.29	80	1.17
40	1.92	90	1.07
50	1.66	100	0.98



- NOTES:
1. ALL DIMENSIONS BASED ON NOMINAL VALUES.
 2. SAMTEC RECOMMENDS FULLY MATING COMPONENTS.
 3. MAXIMUM ALLOWABLE ANGLE AT FULLY MATED NOMINAL CONDITIONS.

PROPRIETARY NOTE

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e-Mail: info@SAMTEC.com code: 55322

REVISION A | APF6-APM6 Misalignment Document

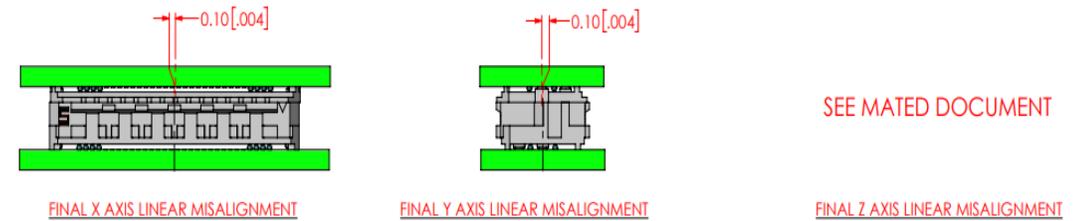


TABLE 4

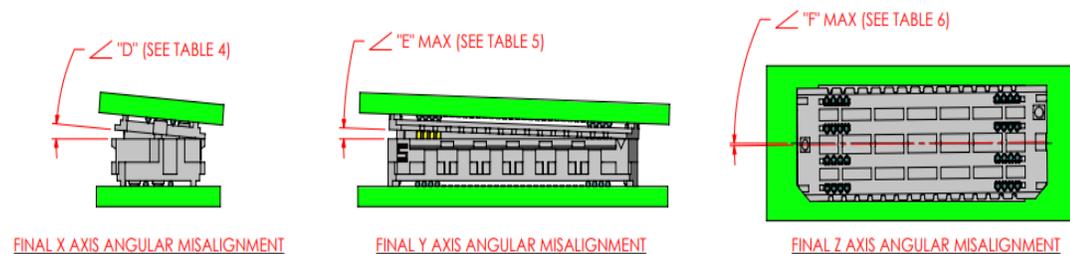
ROW	"D"=DEG
4	3.95
6	2.56
8	1.89
10	1.50
16	0.92

TABLE 5

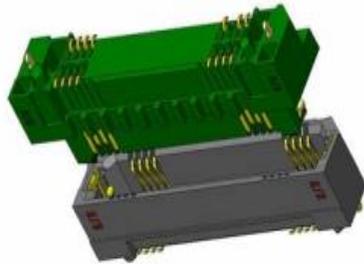
NO OF POS	"E"=DEG	NO OF POS	"E"=DEG
10	3.30	60	0.79
20	2.02	70	0.69
30	1.46	80	0.61
40	1.14	90	0.54
50	0.93	100	0.49

TABLE 6

NO OF POS	"F"=DEG	NO OF POS	"F"=DEG
10	1.12	60	0.27
20	0.69	70	0.23
30	0.50	80	0.21
40	0.39	90	0.19
50	0.32	100	0.17



Supplemental Test Reports & Qualification Reports



Mating and Unmating Testing on 10, 30, & 75 Position Assemblies with and without Latches.

PART DESCRIPTION

ERX8 Series

RESULTS

Mating – Unmating Forces 10 Position (without latches)

- Initial
 - Mating
 - Min ----- 1.1 Lbs.
 - Max ----- 1.8 Lbs.
 - Unmating
 - Min ----- 0.6 Lbs.
 - Max ----- 1.5 Lbs.
- After 25 Cycles
 - Mating
 - Min ----- 1.1 Lbs.
 - Max ----- 1.7 Lbs.
 - Unmating
 - Min ----- 0.5 Lbs.
 - Max ----- 1.4 Lbs.
- After 50 Cycles
 - Mating
 - Min ----- 1.0 Lbs.
 - Max ----- 1.8 Lbs.
 - Unmating
 - Min ----- 0.6 Lbs.
 - Max ----- 1.4 Lbs.
- After 100 Cycles
 - Mating
 - Min ----- 1.0 Lbs.
 - Max ----- 1.9 Lbs.
 - Unmating
 - Min ----- 0.6 Lbs.
 - Max ----- 1.5 Lbs.
- After 200 Cycles
 - Mating
 - Min ----- 1.1 Lbs.
 - Max ----- 2.1 Lbs.
 - Unmating
 - Min ----- 0.7 Lbs.
 - Max ----- 1.6 Lbs.

Mating – Unmating Forces 10 Position (with latches)

- Initial
 - Mating
 - Min ----- 3.5 Lbs.
 - Max ----- 4.2 Lbs.
 - Unmating
 - Min ----- 7.3 Lbs.
 - Max ----- 10.7 Lbs.
- After 25 Cycles
 - Mating
 - Min ----- 3.4 Lbs.
 - Max ----- 4.1 Lbs.
 - Unmating
 - Min ----- 9.0 Lbs.
 - Max ----- 11.1 Lbs.
- After 50 Cycles
 - Mating
 - Min ----- 3.3 Lbs.
 - Max ----- 4.1 Lbs.
 - Unmating
 - Min ----- 9.3 Lbs.
 - Max ----- 13.8 Lbs.
- After 100 Cycles
 - Mating
 - Min ----- 3.4 Lbs.
 - Max ----- 4.1 Lbs.
 - Unmating
 - Min ----- 12.3 Lbs.
 - Max ----- 13.1 Lbs.
- After 200 Cycles
 - Mating
 - Min ----- 3.5 Lbs.
 - Max ----- 4.5 Lbs.
 - Unmating
 - Min ----- 11.1 Lbs.
 - Max ----- 12.5 Lbs.

Mitigation



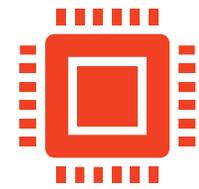
Check your results



Revised recommended
documentation



Use of additional
mechanical retention
features



Placement & fixturing
location



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