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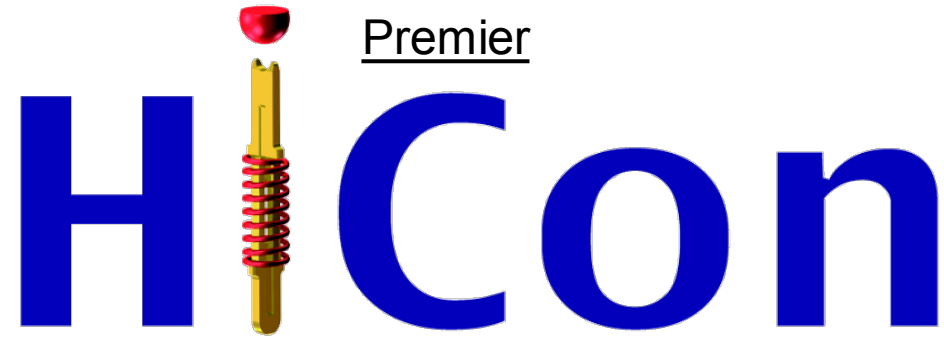
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Mesa, Arizona
March 5-8, 2023

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The Evolution of the Coaxial Contactor and the Advantage of the Modern Version

Jason Mroczkowski
Cohu



Mesa, Arizona • March 5-8, 2023



TestConX 2023

Agenda

- Need for Coaxial Contactors
- Design Comparison
- Simulation
- Measurement
- Summary/Conclusion



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the Advantage of the Modern Version

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The Need for Coaxial Contactors

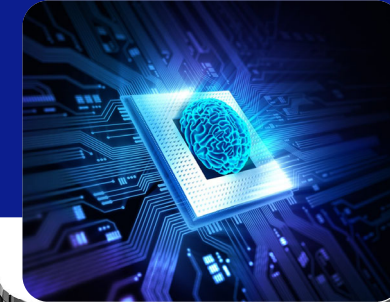
Need: increased density of processors, networking, and RF devices

Device requirements

- Low noise, high gain, advanced power delivery, high data rate, multichannel PAM4

Contactor requirements

- Low loss (1dB >40GHz)
- High isolation (>60dB)
- Low inductance (<0.1nH)
- Matched impedance (+/- 5%)



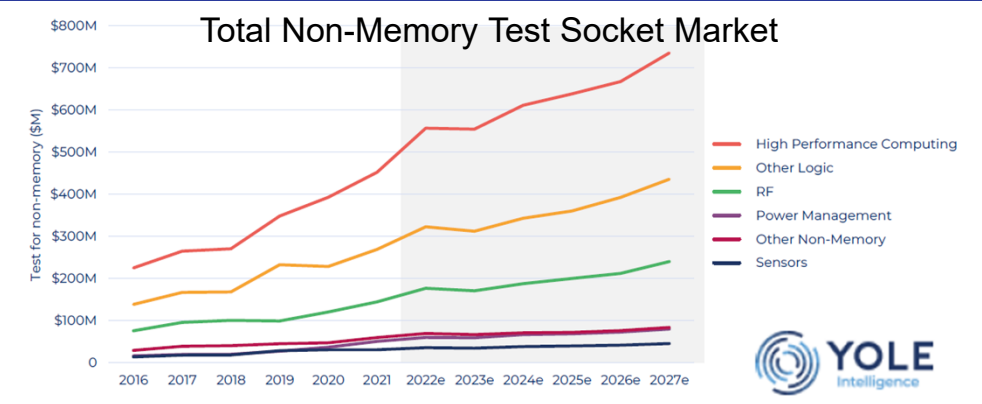
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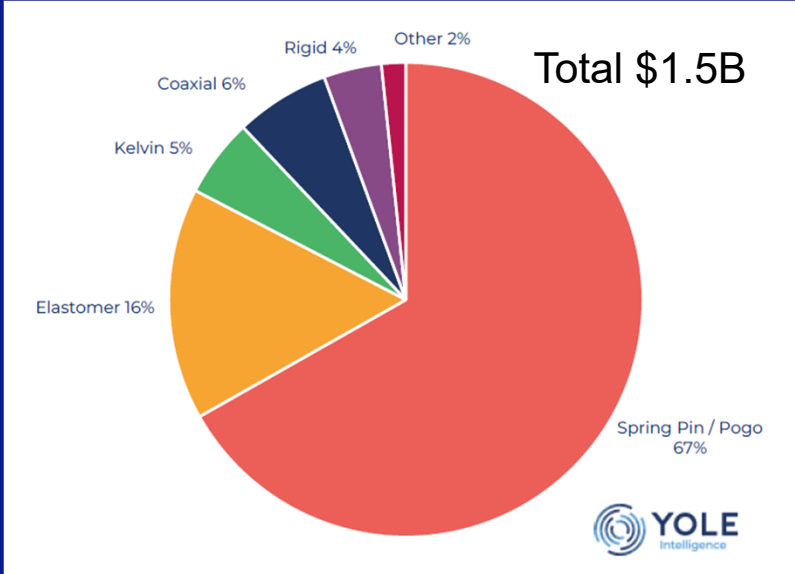
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Coaxial Test Socket Market

- \$90M coaxial market expected for 2022 and 2023



	2016 - 2021 CAGR	2022 - 2027 CAGR
Processors	10.5%	10.1%
Sensors	13.0%	6.5%
RF	8.9%	7.3%
DRAM	17.7%	12.3%
NAND	13.4%	6.5%



- Growth rate of semiconductor units 4.5% CAGR



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Available Coaxial Contactor Types

- Coaxial contactor types

- “Pseudo coax”

- Advantage: lower cost
 - Disadvantage: crosstalk



Pseudo

- Full coaxial contactors

- Advantage: best isolation
 - Disadvantage: complexity



Full

- Manufacturing techniques

- Embedded insulator

- Insulator part of body/retainer

- Component insulator

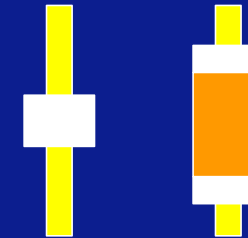
- Insulator independent of body/insulator



Embedded/
component

- Probe insulator

- Insulator on probe



Probe insulators

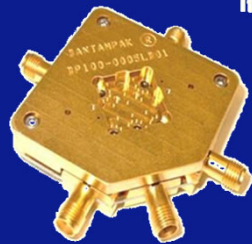


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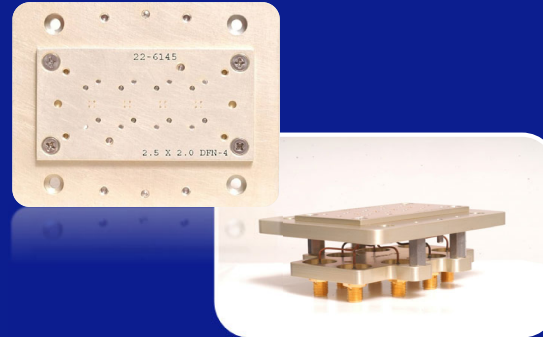
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Early Coaxial Contactor History (ICON Gen 1)



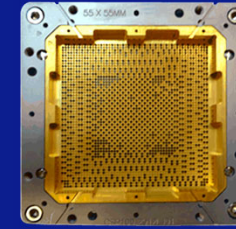
2000

- Integral, impedance-controlled PC board included



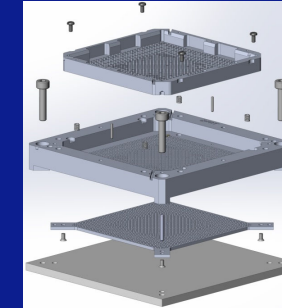
2005

- Quad-site WLCSP contactor
- Semi-rigid coaxial cables from connectors to probes
- High-volume production ready



2010

- 1 mm pitch, 2912 BGA, 55 mm X 55 mm
- 1273 co-axial paths
- Isolation all the way from the board to the DUT



2015

- The need for coaxial contactors has existed for many years
- The challenge is to design coaxial contactors designed for high-volume production test

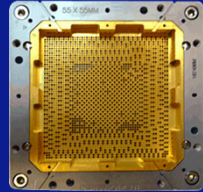


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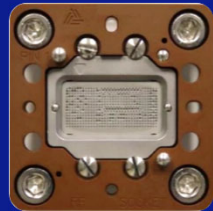
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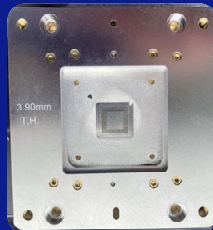
Generations of ICON



- ICON Gen 1 2003
 - Best in class isolation – coax from package to PCB
 - Maintainable – individual probe/insulator replacement
 - High Speed Digital (HSD) BGA focus – 0.8mm pitch +



- ICON Gen 2 2018
 - Same best in class isolation
 - Simple maintainability – embedded insulator
 - Analog RF and HSD applications QFN/BGA/WL down to 0.4mm pitch



- ICON Gen 3 2022
 - Same best in class isolation
 - Lowest initial cost – simplified manufacturing process / batch processing
 - Most flexible design – impedance matching from 25-100 ohms at pitches <0.4mm
 - Simplest maintainability – fixed and replaceable insulators

Version	Gen1	Gen2	Gen3
Performance	Green	Green	Green
HSD	Green	Green	Green
Analog	Orange	Green	Green
Wafer	Orange	Green	Green
Cost	Orange	Yellow	Green
Fine Pitch	Orange	Yellow	Green
Maintenance	Orange	Yellow	Green



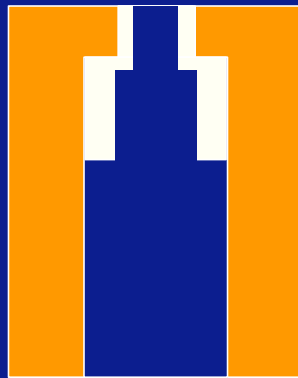
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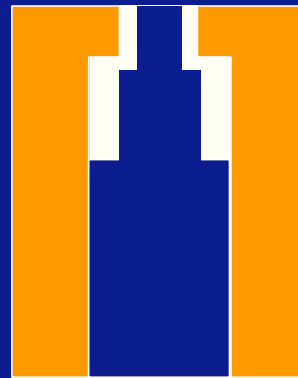
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ICON Assembly

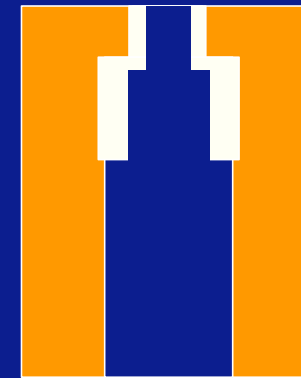
- Gen 1



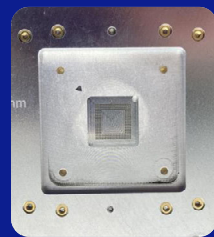
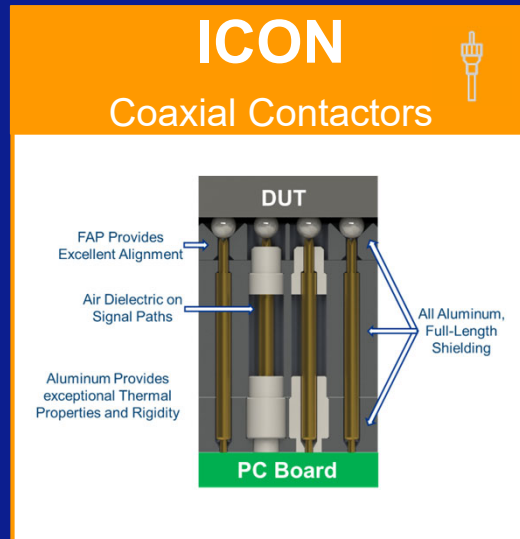
- Gen 2



- Gen 3



ICON Contactors - Impedance Controlled Coaxial

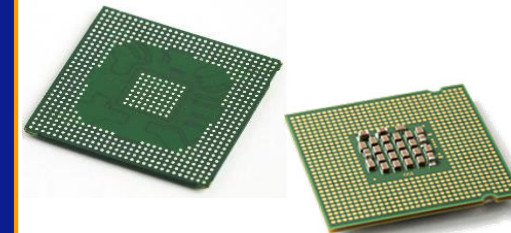


- Features & Benefits
 - Signal paths surrounded by ground from DUT Interconnect to PCB pad
 - Field repairability for insulators
 - Tuned Impedance that is not affected by the proximity of device grounds (e.g., 35 Ω, 42 Ω, 50 Ω, 86 Ω, etc.)
 - Excellent conductive heating/cooling
 - Combine with Hydra to maximize power and signal integrity

Key Specification	Value
Pitch	0.4mm, 0.8mm and 1.0mm versions
Package Types	BGA, LGA, QFN, QFP
Bandwidth (Insertion Loss) Max Data Rate	> 60GHz @ -1dB > 120Gbps
Isolation	> 50 dB
Current Carrying Capacity	Up to 2.9A continuous
Temperature Range	-55°C to 155°C

Applications

Ideal for FPGA, GPU, xPU, DDR, PAM4, HDMI, PCIe and all package types



Optimized for Hydra



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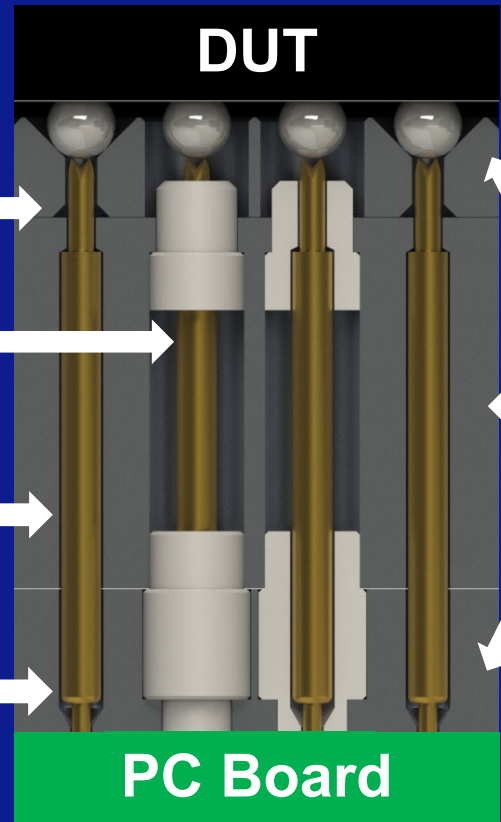
ICON Coaxial Design – Features

Aluminum floating alignment plate provides excellent alignment and ground for complete isolation up to the DUT

Air dielectric on signal probes provides less loss

Aluminum body provides exceptional thermal properties and rigidity along with great signal isolation

Aluminum retainer plate holds the probes in the body and provides complete isolation to the test interface board



All aluminum, full-length signal shielding

Isolation from the DUT to the Test System

Aluminum body has the stiffness to avoid bowing in when used with large parts

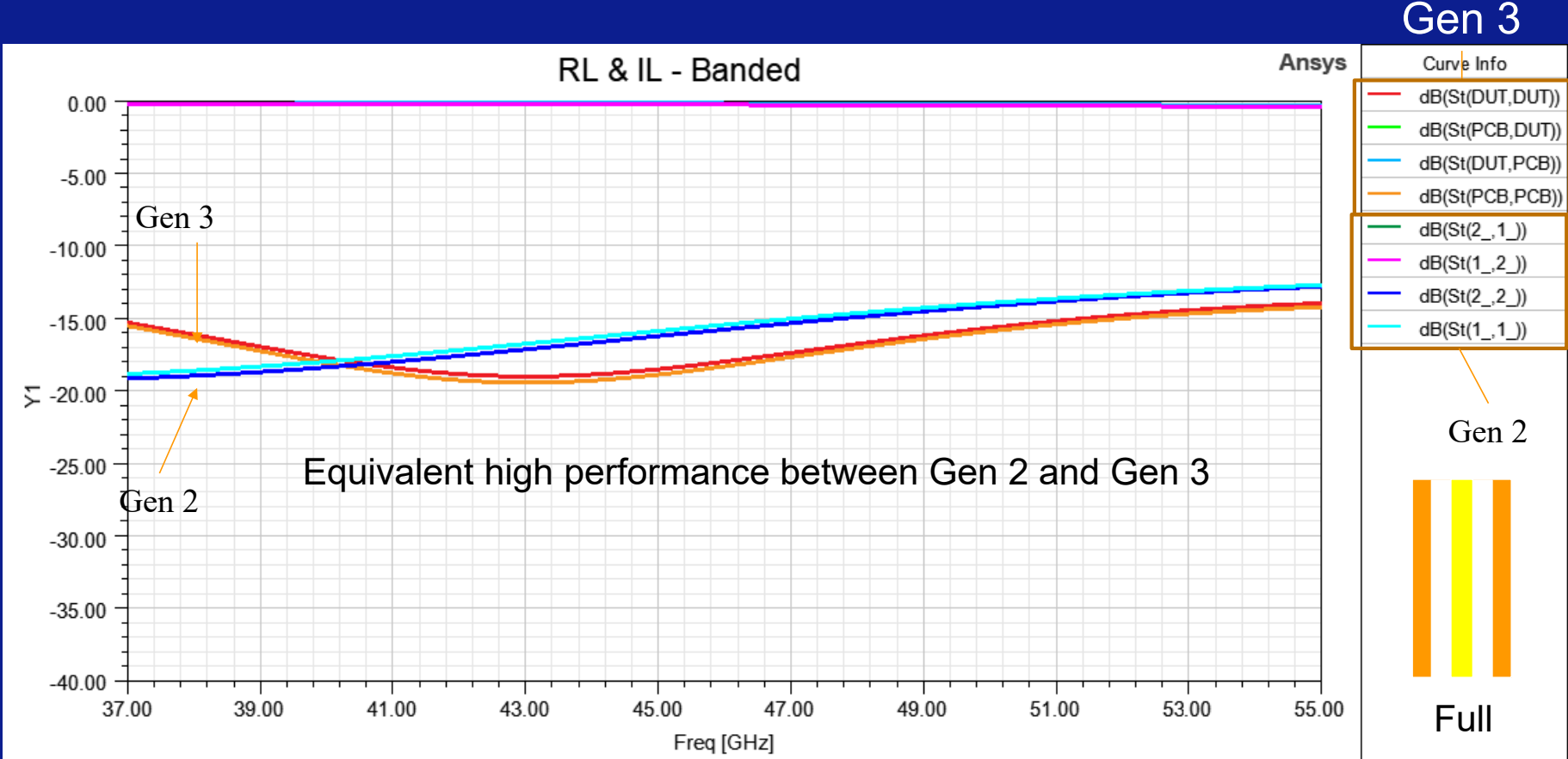


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Gen 2 35Ω & Gen 3 35Ω - 37-55GHz



The Evolution of the Coaxial Connector and the Advantage of the Modern Version

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ICON vs Pseudo Coax

- Full coax shows ~20dB better isolation
- Below -45dB to 60GHz

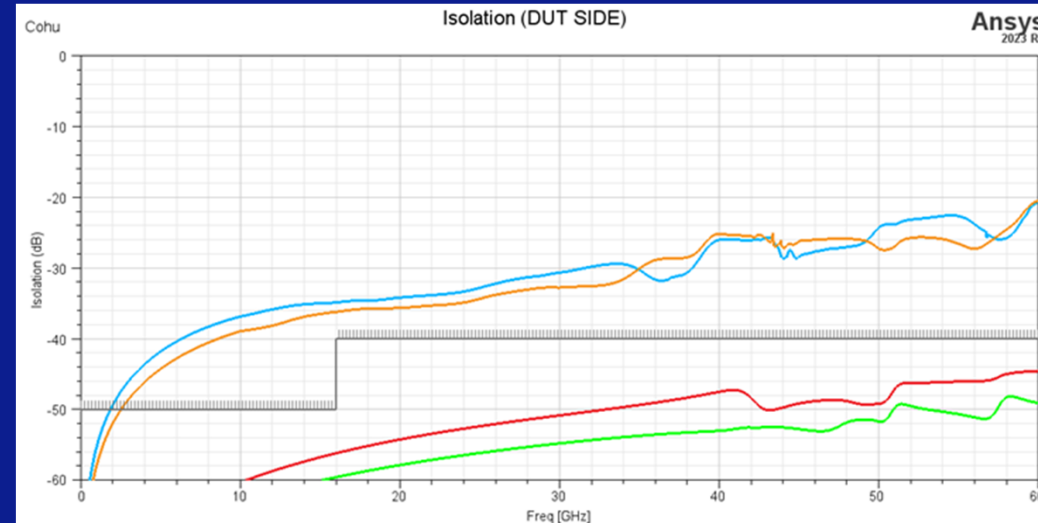
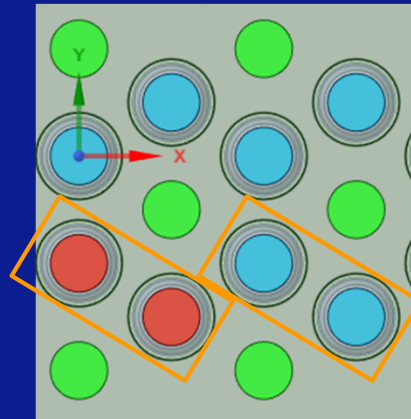


ICON



Pseudo

Key:
 Signal (Victim)
 Ground
 Nearby RF (Aggressor)
 Matched (50Ω)



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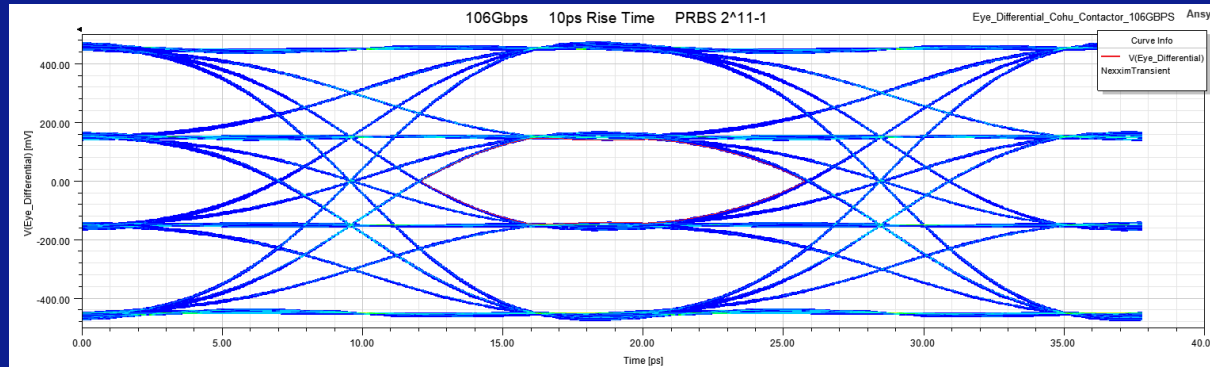
Loop Inductance - 25Ω Single Ended



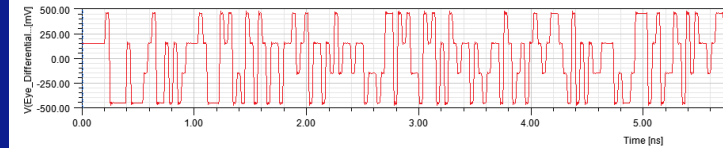
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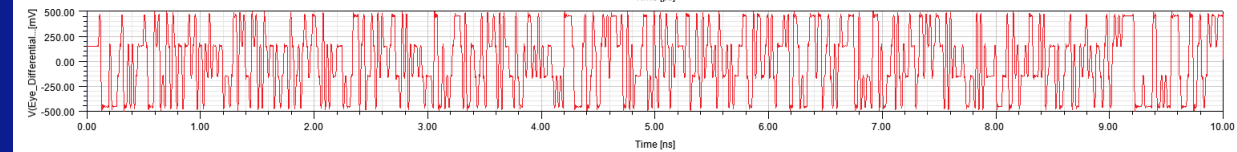
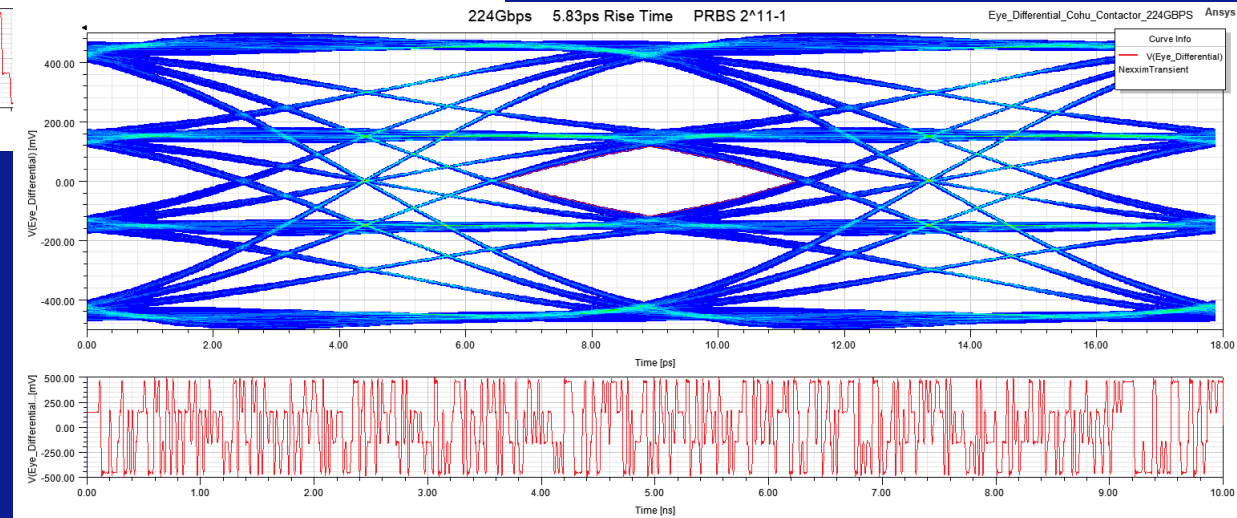
ICON 3.0 Contactor Eye Diagram



106GBPS SERDES



224GBPS SERDES



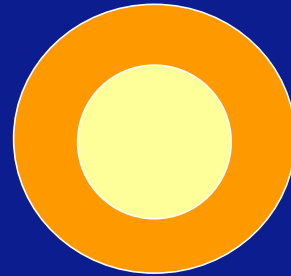
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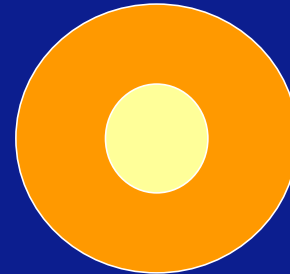
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Impedance Controlled Coax Options

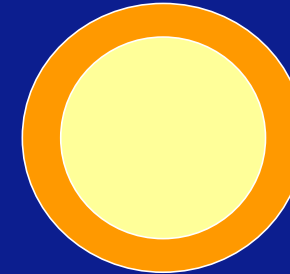
50 Ohm



75 Ohm



25 Ohm



Pitch	Impedance	Customer	Application
40	50, 35	A	Transceiver
50	50	B	Satellite
50	42, 85D	C	Processor
80	50D, 100D	D	ADC
80	43, 86D	E	Processor



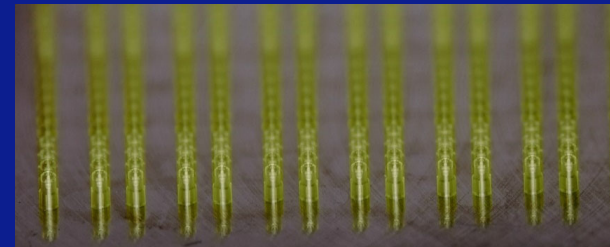
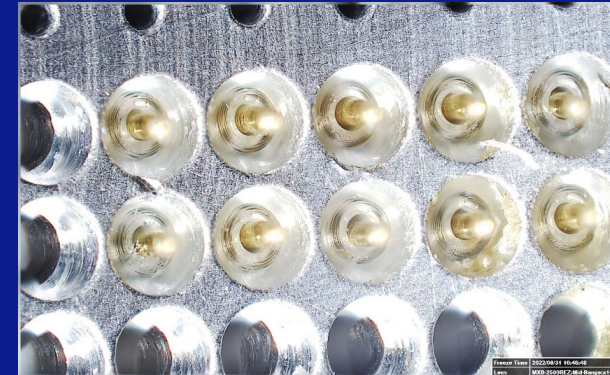
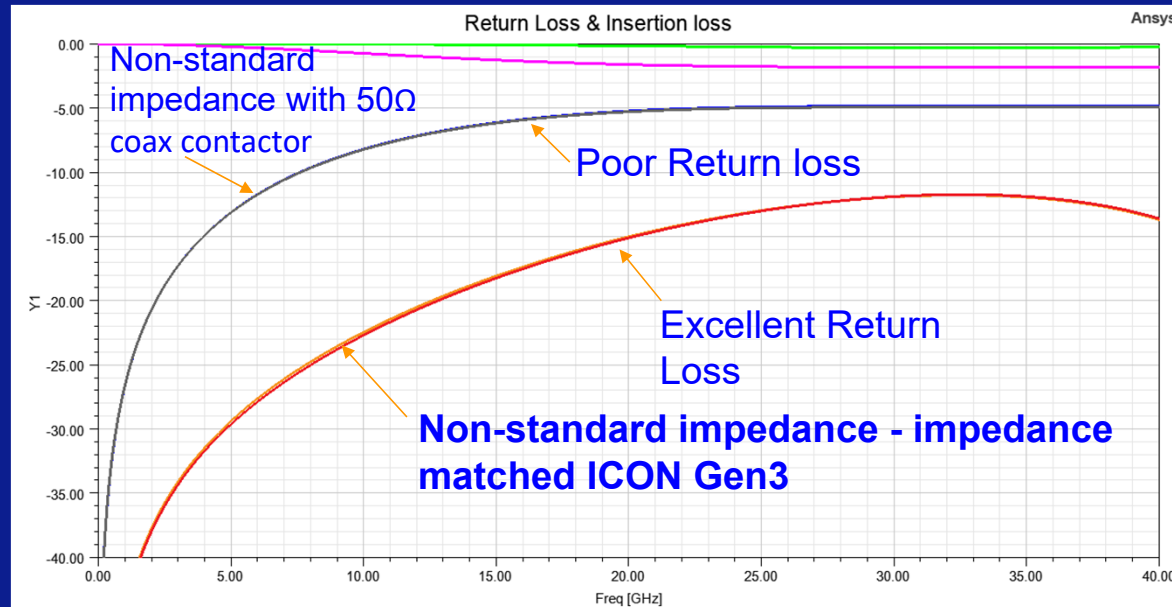
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Below and Beyond the Competition

- ICON Gen3 optimized for non-standard impedances
 - Typical coaxial contactors only available in 50 Ω

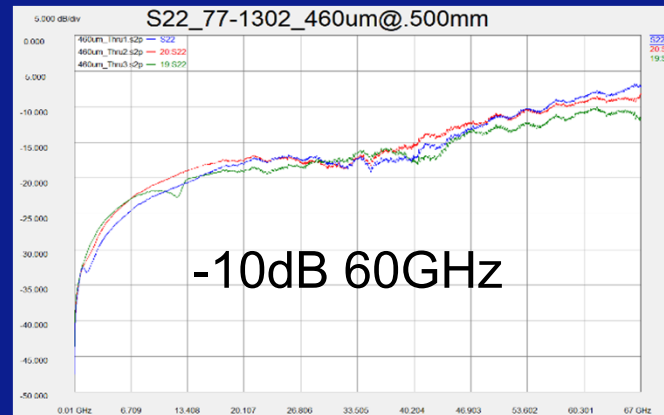
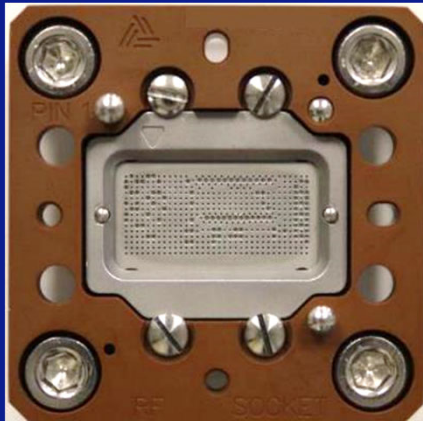
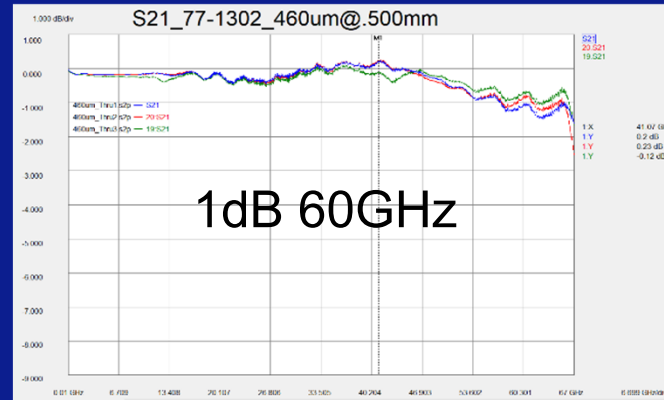
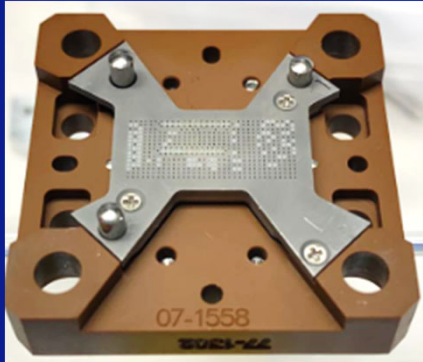


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ICON 040 – Measured Performance @ 0.37mm pitch

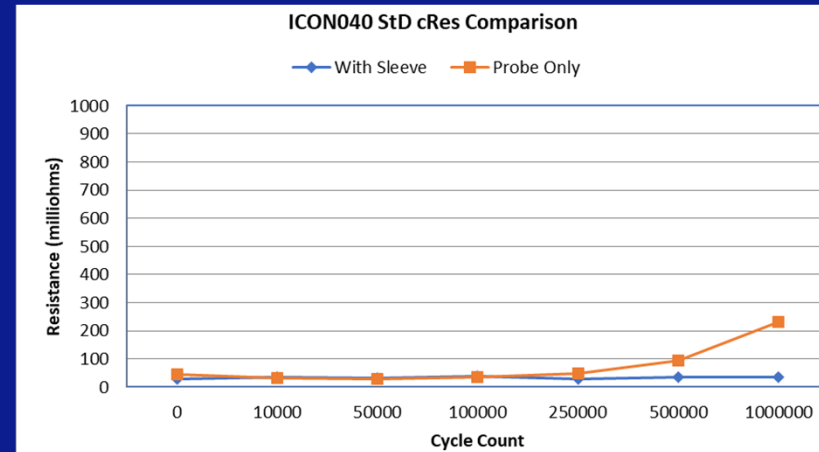
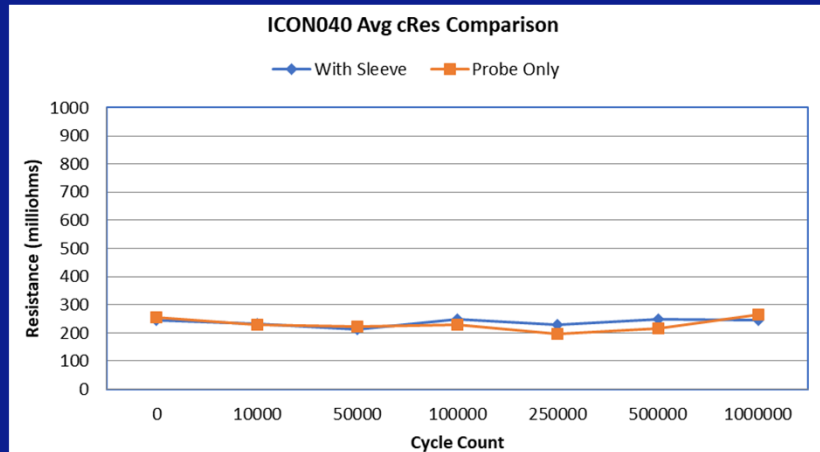


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ICON Life Cycle Testing

- ICON040 using cViper020 probe shows stable cRes thru 1M cycles



Cycle Count	0		10,000		50,000		100,000		250,000		500,000		1,000,000	
	With Sleeve	Probe Only	With Sleeve	Probe Only	With Sleeve	Probe Only	With Sleeve	Probe Only	With Sleeve	Probe Only	With Sleeve	Probe Only	With Sleeve	Probe Only
Average Resistance (milliohms):	245.15	255.60	233.20	228.80	213.54	223.87	247.58	229.95	229.80	196.15	249.20	215.95	245.20	263.68
Std Dev Resistance (milliohms):	27.87	44.36	34.03	33.67	33.41	30.46	37.62	34.66	30.30	47.27	34.70	95.27	35.70	232.18
Max Resistance (milliohms):	346.30	568.02	329.18	474.26	436.07	385.02	352.51	439.23	325.40	630.78	356.30	1638.40	361.30	3484.60
Min Resistance (milliohms):	181.94	188.80	177.55	171.94	172.88	176.53	182.03	171.32	188.70	122.42	190.80	158.79	179.90	171.94



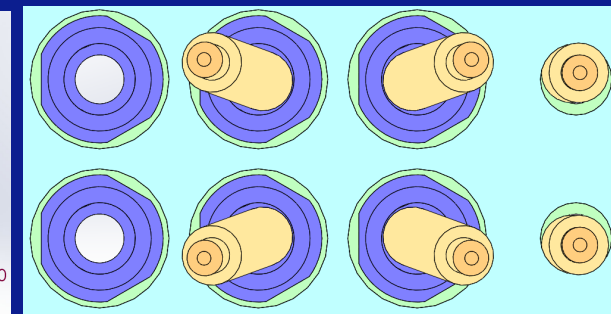
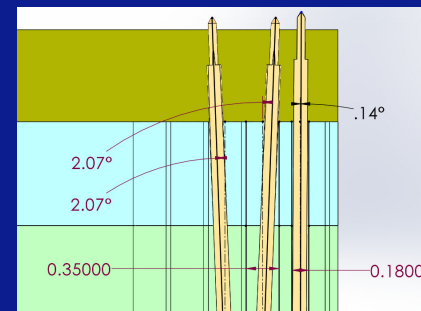
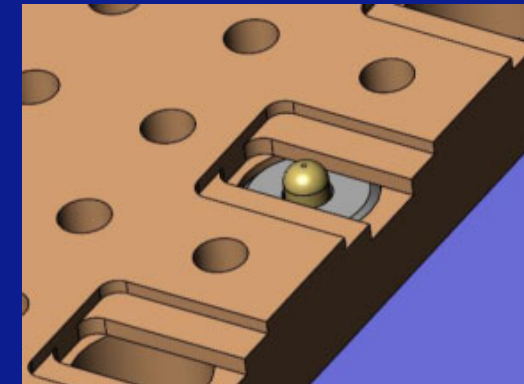
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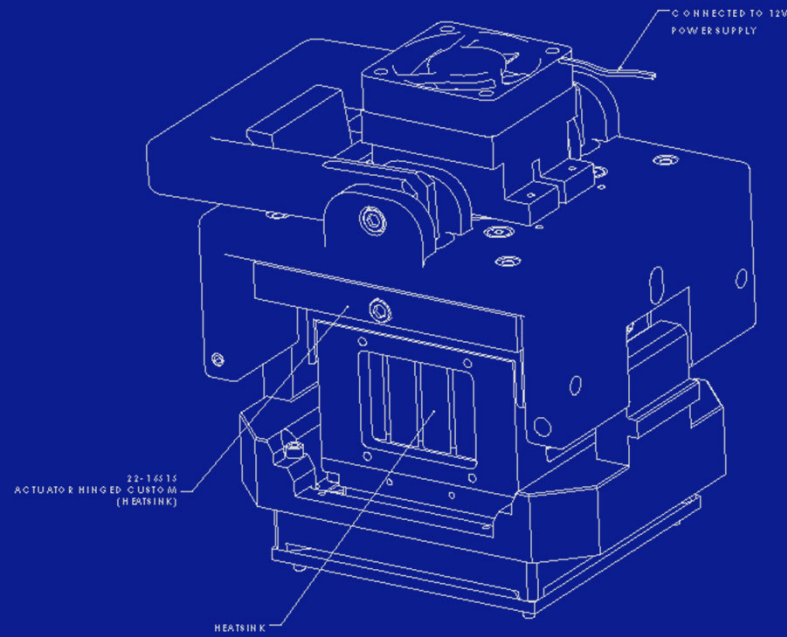
Coaxial Contactor Considerations

Must consider contactor and PCB as system

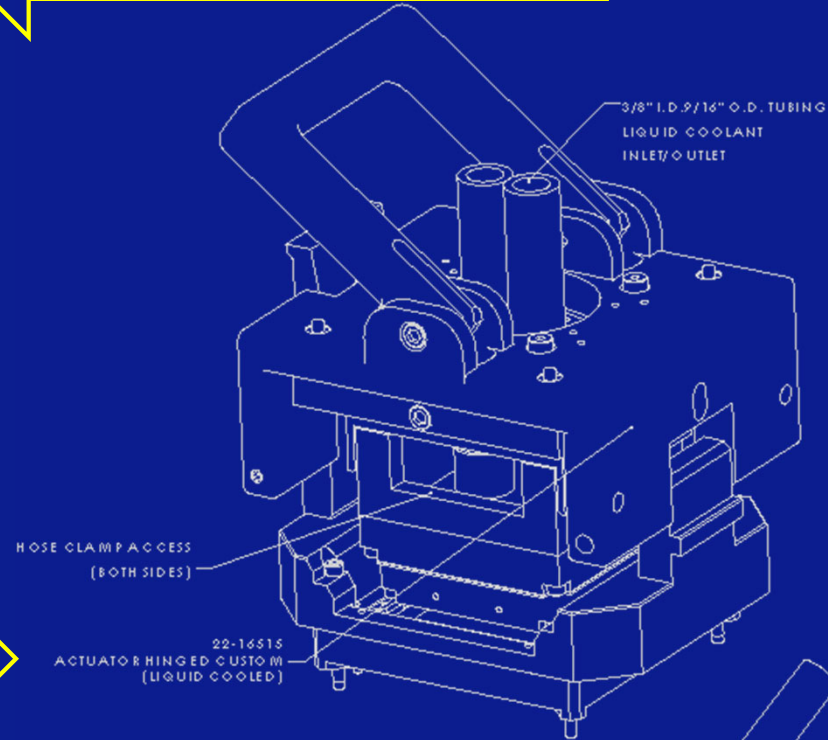
- Need to incorporate channels for surface traces
- Optimization recommended for impedance matching including board trace geometry
- Best repeatability requires DUT and PCB ground contact
- Assembly and probe tilt



Manual Actuator Options



Fan-Cooled High-Force MA



Liquid-Cooled High-Force MA



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Next Steps

- Short term
 - Measure wear after 1M cycles
 - Temperature testing
- Long term
 - Fine pitch – less than 0.3mm pitch
 - Embedded thermal control
 - Further component cost reduction
 - Manufacturing automation for extreme HVM



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Conclusion

- ICON has been developed through many years of high- volume semiconductor test expertise
- ICON offers performance and cost advantages for HVM test of high-performance computing, networking and RF applications
- System simulation and measurement correlation recommended to provide full test interfaces optimized for your application
- Must consider cost, maintenance, and performance tradeoffs of coaxial contactor solutions



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