Signal Analysis & Comparison of High-Density Coaxial Test Interfaces

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TestConX
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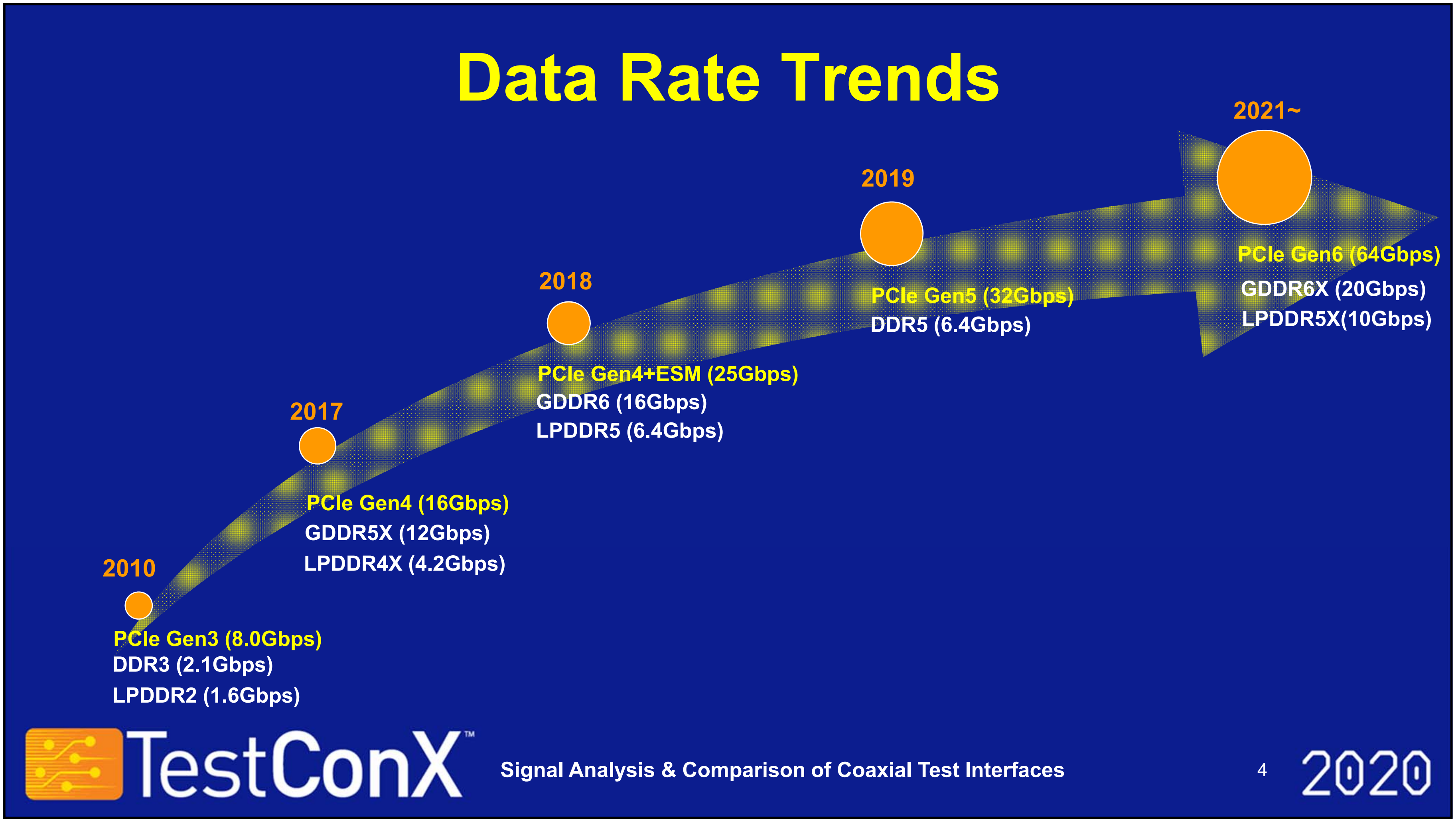
TSE

Outline

- Why High-Density Coaxial Interfaces?
- Data Rate Trends
- Impedance Matching
- Test Socket Structures
- Typical vs. Tunable Elastomer Sockets
- Signal Performance Comparison
- Summary

Why High-Density Coaxial Interfaces?

- **Continuous demand for the faster data transmission rates.**
  - IoT, AI, Augmented & Virtual Reality, etc.
  - GDDR6 : 16Gbps → 18Gbps → 20Gbps
  - PCIe : Gen4 16Gbps → Gen5 32Gbps → Gen6 64Gbps
  - Ethernet : 25Gbps → 50Gbps → 100Gbps
- **High Density Coaxial Interfaces are needed for…..**
  - Improved signal performance that can keep pace with data rates
  - Interconnect formats that can scale with electrical compatibility
    - ✓ Device Characterization
    - ✓ High Volume Production
    - ✓ System Level Test


Data Rate Trends
2010
PCIe Gen3 (8.0Gbps)
DDR3 (2.1Gbps)
LPDDR2 (1.6Gbps)
2017
PCIe Gen4 (16Gbps)
GDDR5X (12Gbps)
LPDDR4X (4.2Gbps)
2018
PCIe Gen4+ESM (25Gbps)
GDDR6 (16Gbps)
LPDDR5 (6.4Gbps)
2019
PCIe Gen5 (32Gbps)
DDR5 (6.4Gbps)
2021~
PCIe Gen6 (64Gbps)
GDDR6X (20Gbps)
LPDDR5X(10Gbps)
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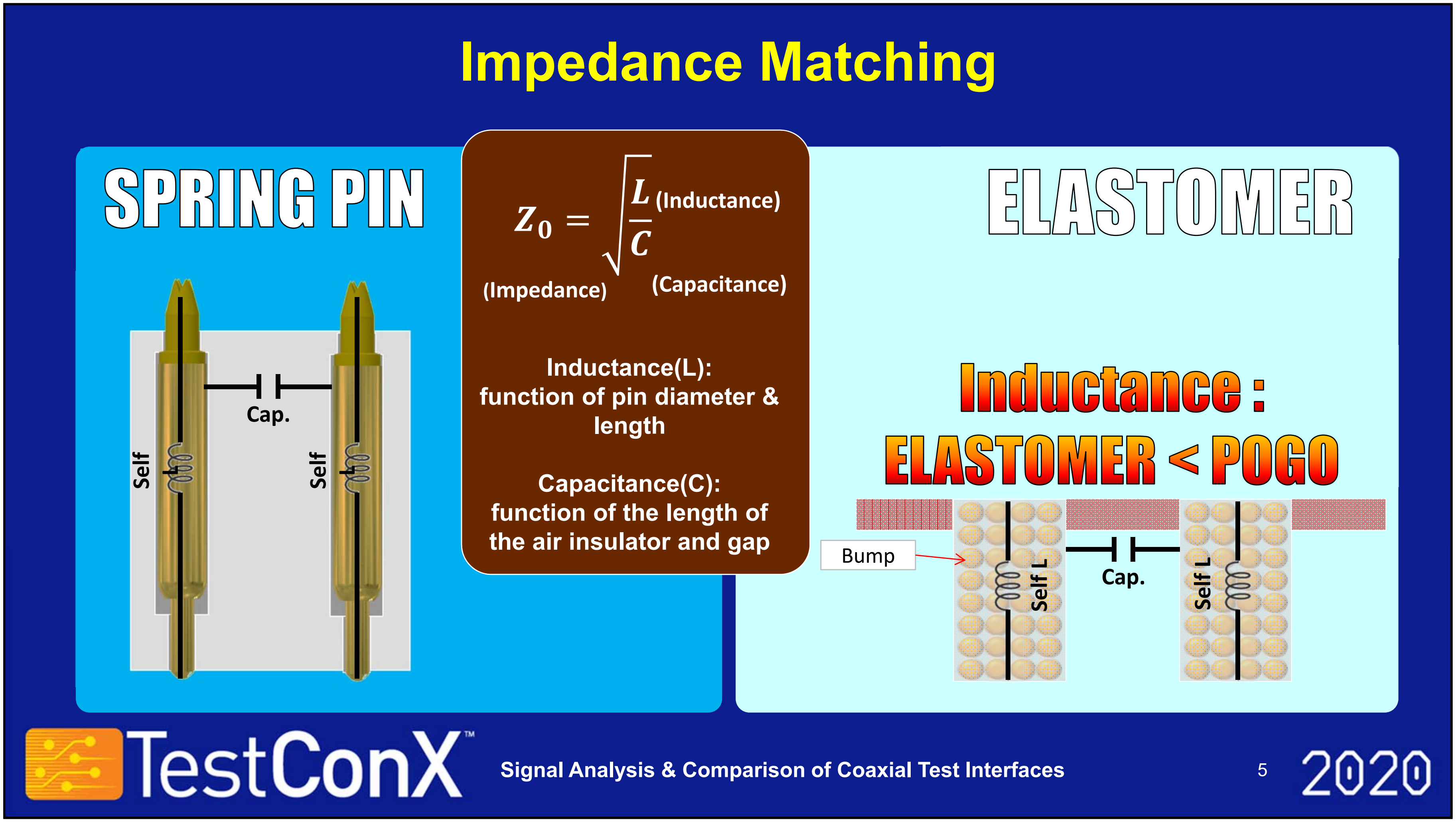
Impedance Matching
SPRING PIN
$Z_0 = \sqrt{\frac{L}{C}}$
(Inductance)
(Impedance)
(Capacitance)
Inductance(L):
function of pin diameter & length
Capacitance(C):
function of the length of the air insulator and gap
ELASTOMER
Inductance :
ELASTOMER < POGO
Cap.
Self
Self
Bump
Self L
Self L
Cap.
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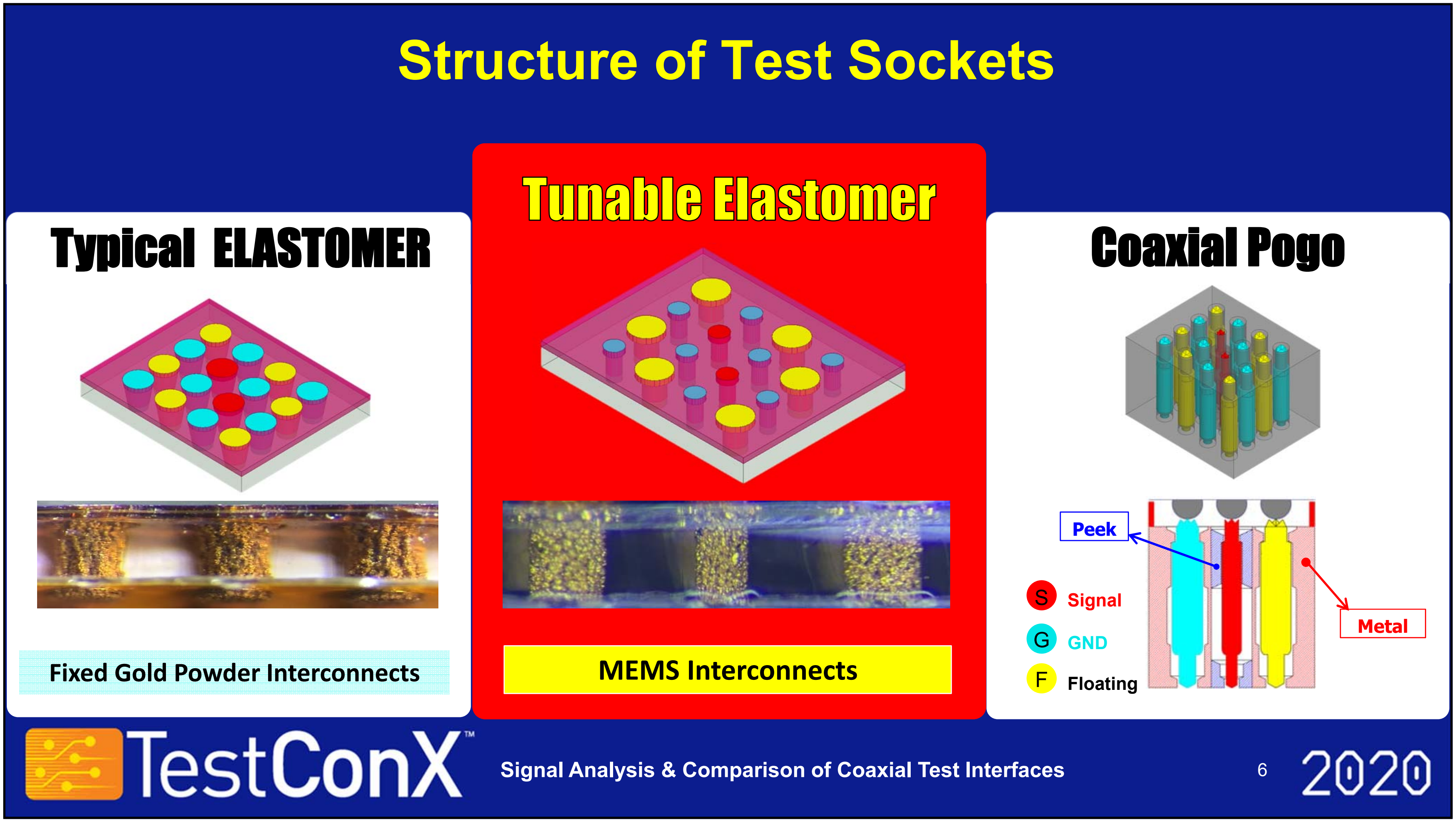
Structure of Test Sockets
Typical ELASTOMER
Fixed Gold Powder Interconnects
Tunable Elastomer
MEMS Interconnects
Coaxial Pogo
Peek
S Signal
G GND
F Floating
Metal
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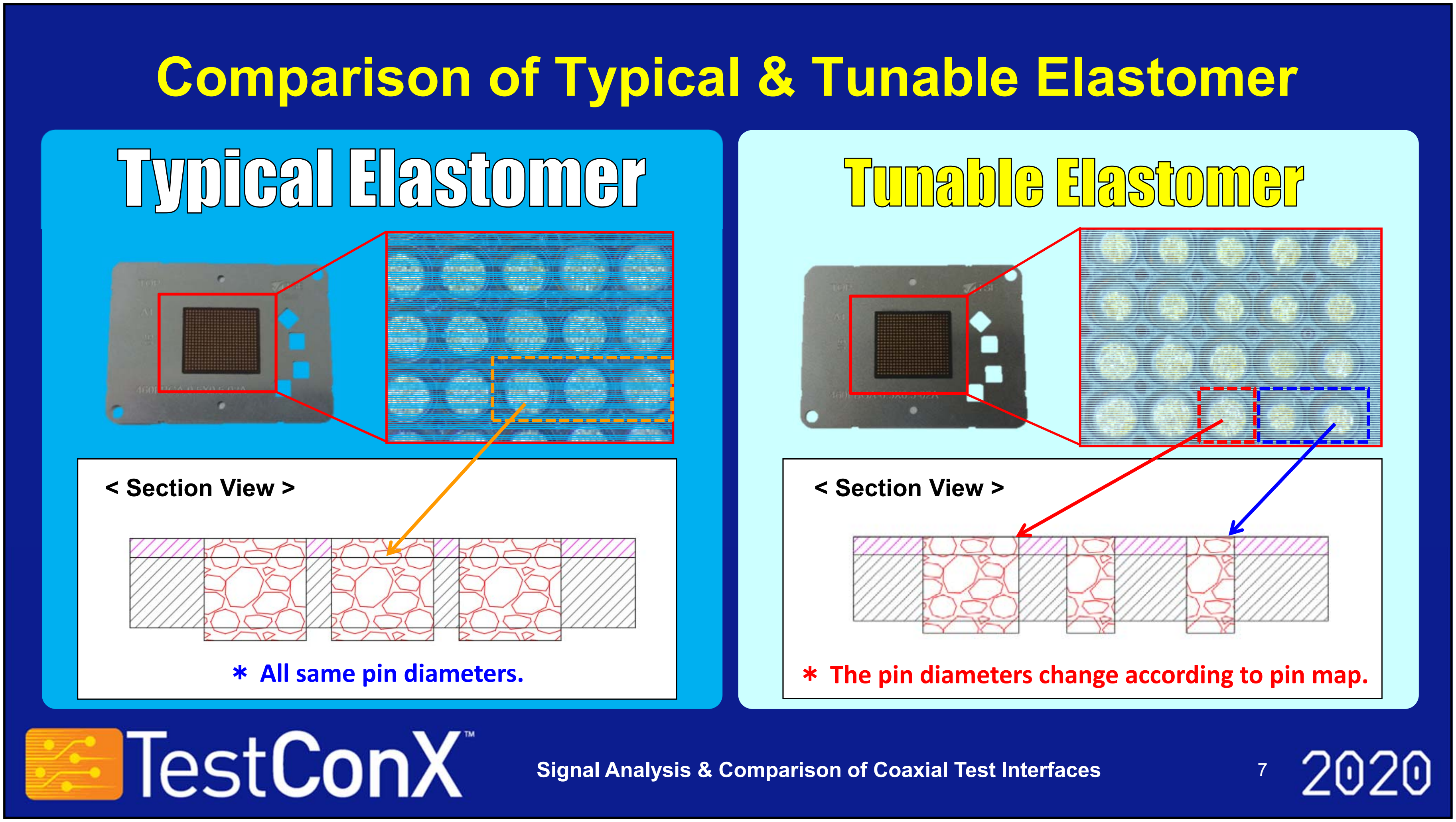

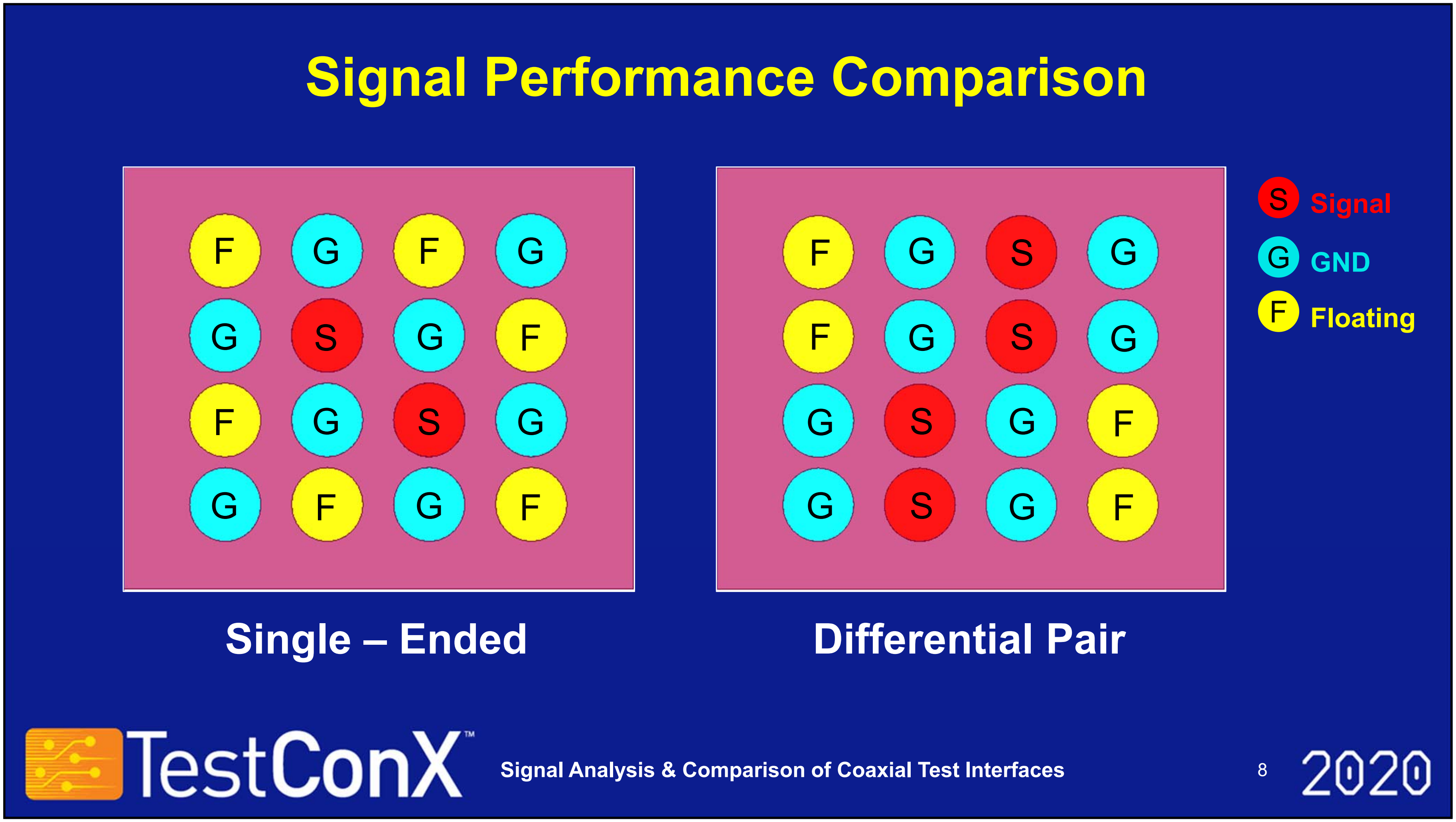

Signal Performance Comparison
F G F G
G S G F
F G S G
G F G F
Single – Ended
F G S G
F G S G
G S G F
G S G F
Differential Pair
S Signal
G GND
F Floating
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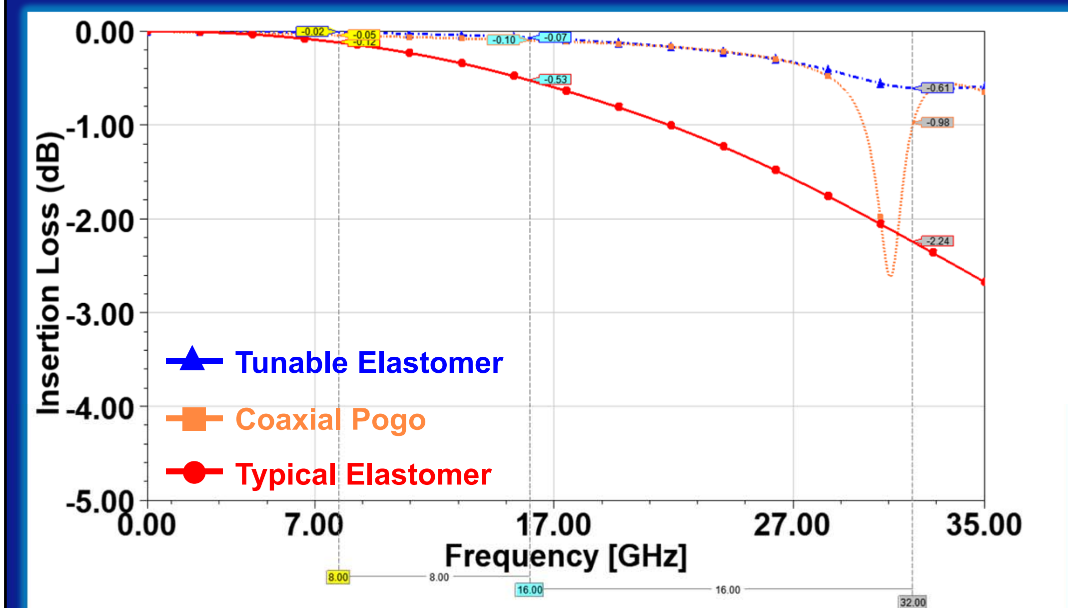
SI Performance Comparison – Single Ended

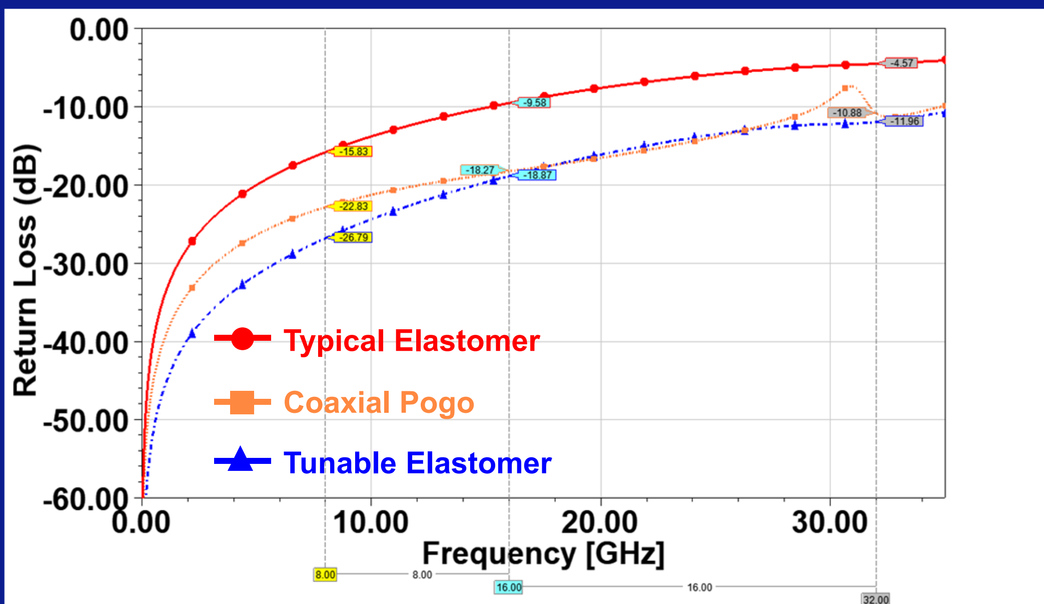
Insertion Loss



Data rate	Insertion Loss (dB)		
	Typical Elastomer	Tunable Elastomer	Coaxial Pogo
16Gbps	-0.12dB	-0.02dB	-0.05dB
32Gbps	-0.53dB	-0.07dB	-0.10dB
64Gbps	-2.24dB	-0.61dB	-0.98dB

SI Performance Comparison – Single Ended

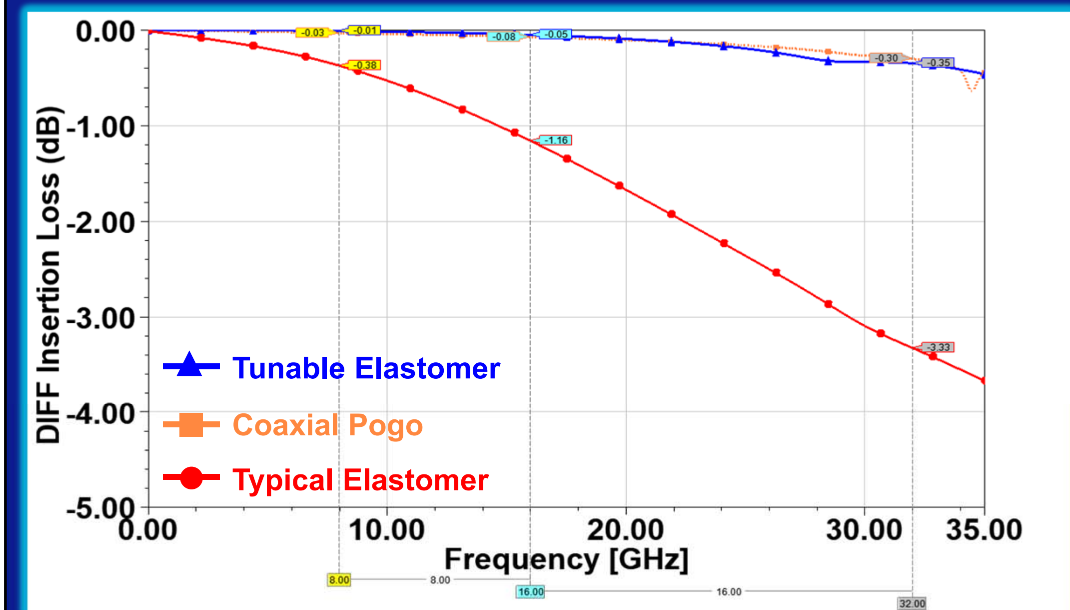
Return Loss



Data rate	Return Loss (dB)		
	Typical Elastomer	Tunable Elastomer	Coaxial Pogo
16Gbps	-15.83dB	-26.79dB	-22.83dB
32Gbps	-9.58dB	-18.87dB	-18.27dB
64Gbps	-4.57dB	-11.96dB	-10.88dB

SI Performance Comparison – Differential Pair

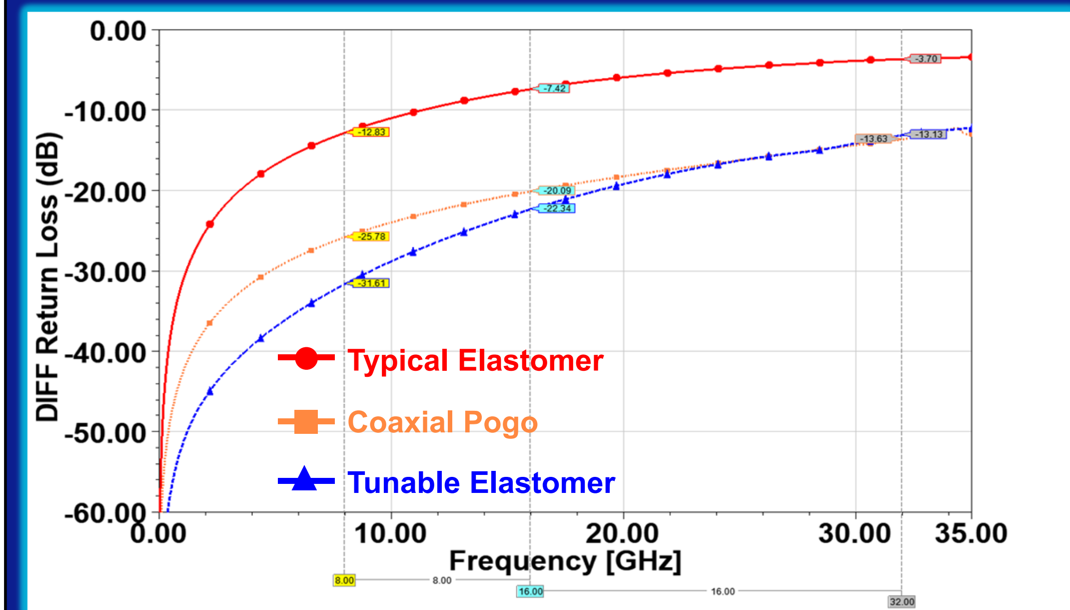
DIFF Insertion Loss



Data rate	DIFF Insertion Loss (dB)		
	Typical Elastomer	Tunable Elastomer	Coaxial Pogo
16Gbps	-0.38dB	-0.01dB	-0.03dB
32Gbps	-1.16dB	-0.05dB	-0.08dB
64Gbps	-3.33dB	-0.35dB	-0.30dB

SI Performance Comparison – Differential Pair

DIFF Return Loss



Data rate	DIFF Return Loss (dB)		
	Typical Elastomer	Tunable Elastomer	Coaxial Pogo
16Gbps	-12.83dB	-31.61dB	-25.78dB
32Gbps	-7.42dB	-22.34dB	-20.09dB
64Gbps	-3.70dB	-13.13dB	-13.63dB

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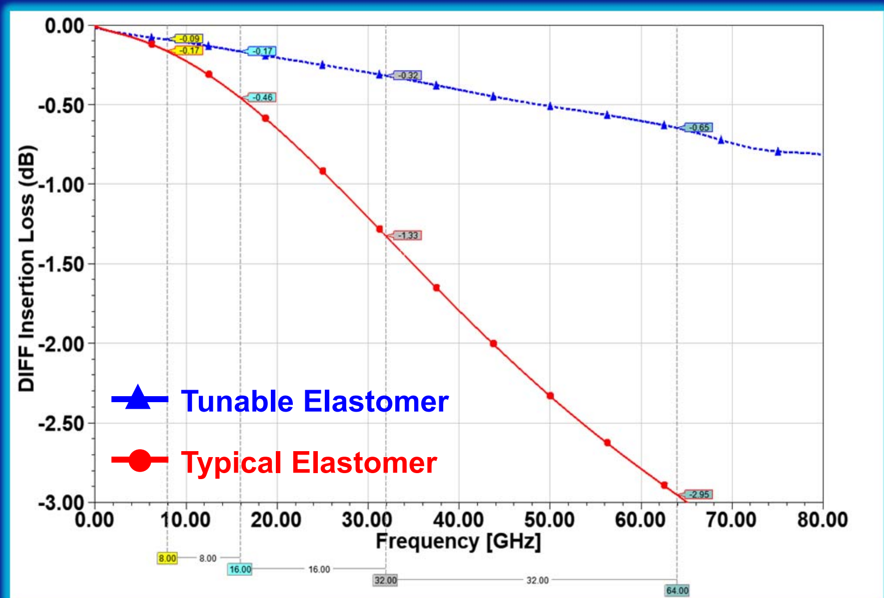
SI Performance Comparison

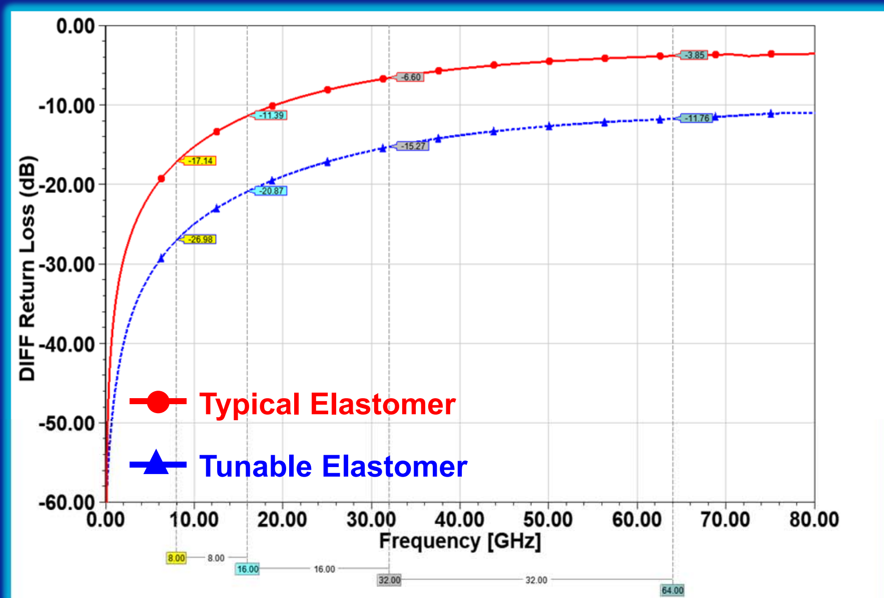
DIFF Insertion Loss



DIFF	Typical Elastomer	Tunable Elastomer	Gap
16Gbps	-0.17dB	-0.09dB	0.08dB
32Gbps	-0.46dB	-0.17dB	0.29dB
64Gbps	-1.33dB	-0.32dB	1.01dB
128Gbps	-2.95dB	-0.65dB	2.30dB

SI Performance Comparison

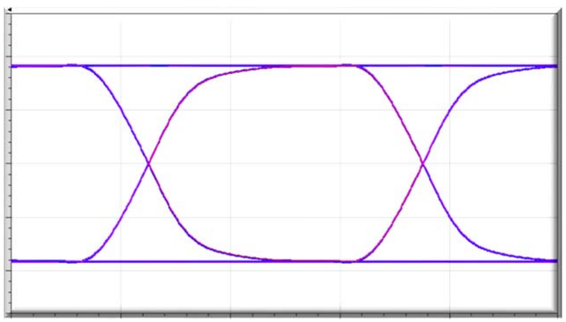
DIFF Return Loss



DIFF	Typical Elastomer	Tunable Elastomer	Gap
16Gbps	-17.14dB	-26.98dB	9.84dB
32Gbps	-11.39dB	-20.87dB	9.48dB
64Gbps	-6.60dB	-15.27dB	8.67dB
128Gbps	-3.85dB	-11.76dB	7.91dB

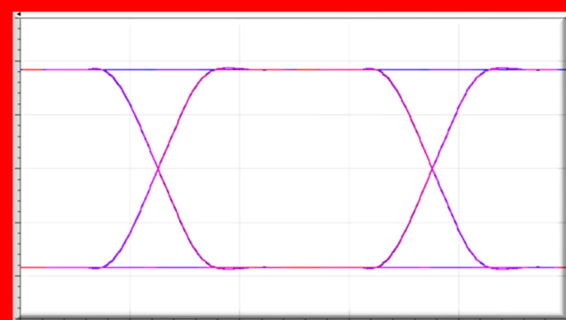
SI Performance Comparison (16Gbps)

Typical ELASTOMER



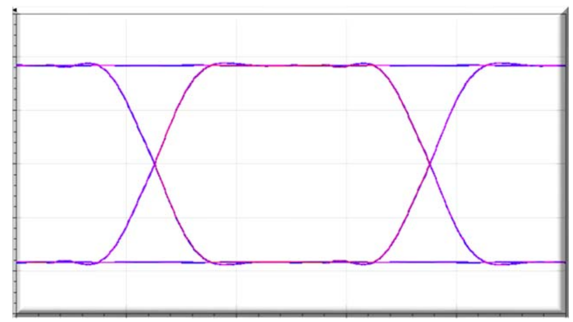
- Eye Height : 900.49
- Eye Width : 62.32
- Jitter : 0.36

Tunable Elastomer



- Eye Height : 915.69
- Eye Width : 62.50
- Jitter : 0.15

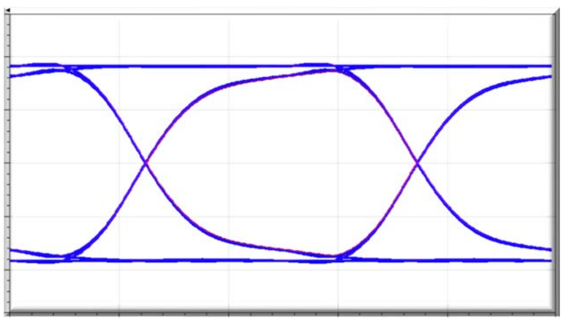
Coaxial Pogo



- Eye Height : 905.88
- Eye Width : 62.43
- Jitter : 0.15

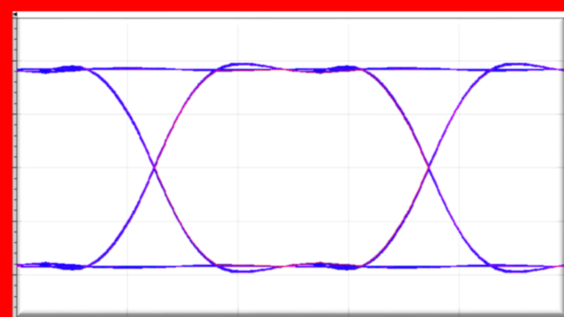
SI Performance Comparison (32Gbps)

Typical ELASTOMER



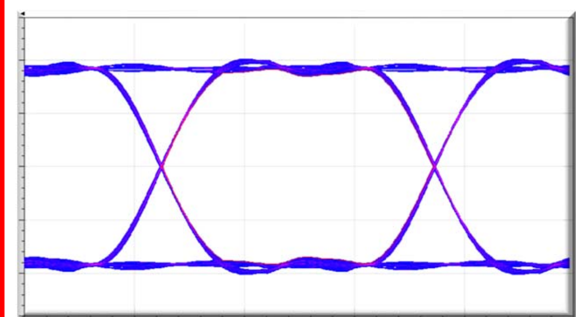
- **Eye Height : 854.80**
- **Eye Width : 30.62**
- **Jitter : 0.44**

Tunable Elastomer



- **Eye Height : 889.93**
- **Eye Width : 30.88**
- **Jitter : 0.16**

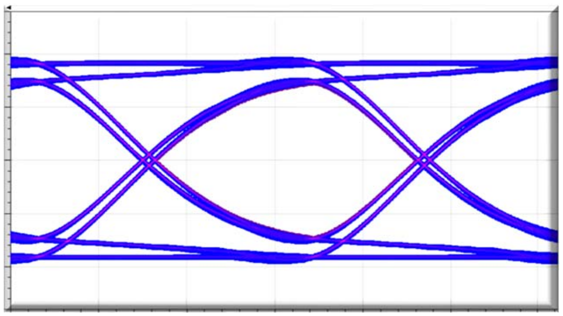
Coaxial Pogo



- **Eye Height : 852.94**
- **Eye Width : 30.75**
- **Jitter : 0.26**

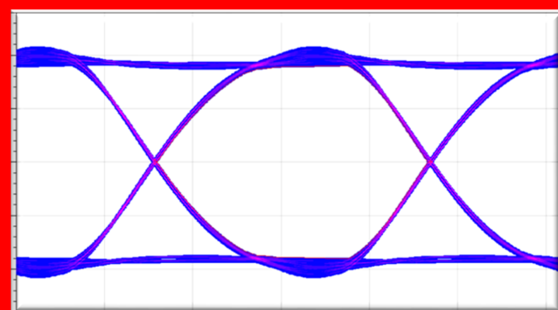
SI Performance Comparison (64Gbps)

Typical ELASTOMER



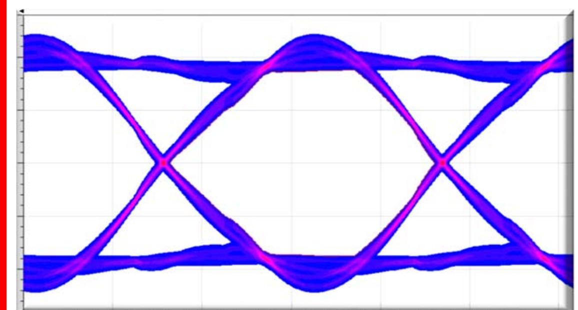
- Eye Height : 714.29
- Eye Width : 14.54
- Jitter : 1.15

Tunable Elastomer



- Eye Height : 879.30
- Eye Width : 15.32
- Jitter : 0.29

Coaxial Pogo



- Eye Height : 848.82
- Eye Width : 14.93
- Jitter : 0.72

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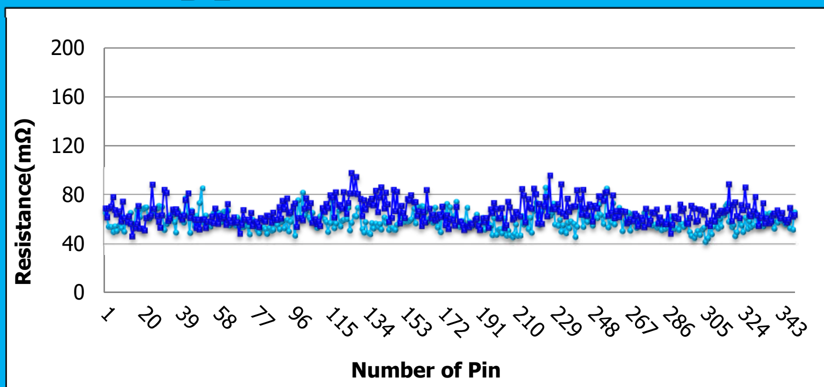
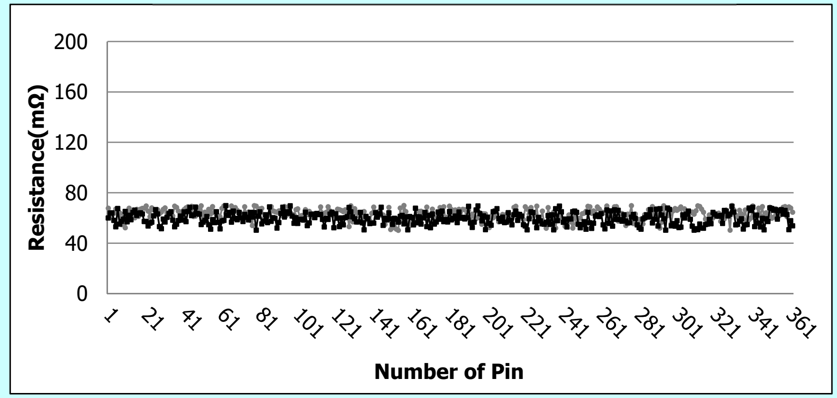
Electrical Performance Comparison - Initial

Typical Elastomer



Cres		#1	#2
Resistance (mΩ)	MIN	41.76	45.97
	MAX	85.68	97.58
	AVG	58.56	65.30
	STD	7.32	8.85

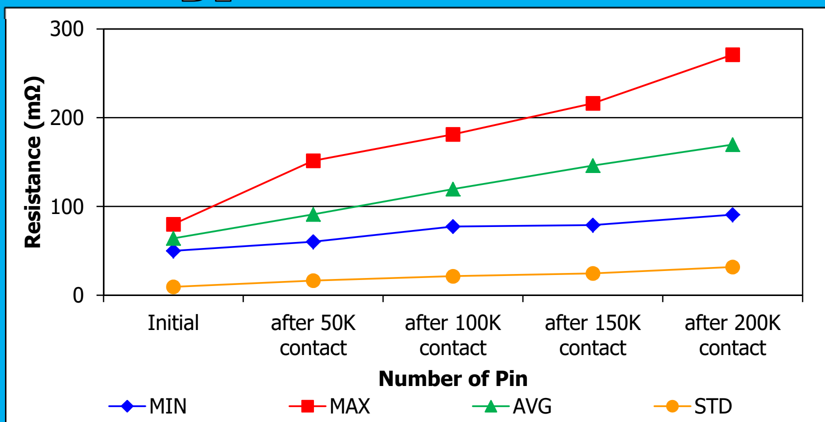
Tunable Elastomer



Cres		#1	#2
Resistance (mΩ)	MIN	50.22	50.34
	MAX	69.90	69.79
	AVG	63.02	59.61
	STD	4.42	4.78

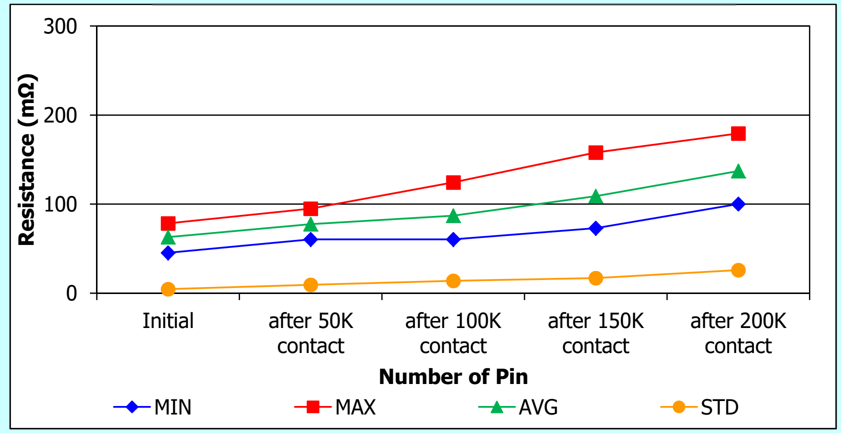
Electrical Performance Comparison – Touch Down

Typical Elastomer



Lifespan by touchdown		Initial	after 50k contact	after 100k contact	after 150k contact	after 200k contact
Resistance (mΩ)	MIN	50.05	60.22	77.47	78.97	90.81
	MAX	79.89	151.50	181.26	216.15	270.94
	AVG	63.96	91.17	119.50	146.02	169.70
	STD	9.40	16.45	21.41	24.62	31.70

Tunable Elastomer



Lifespan by touchdown		Initial	after 50k contact	after 100k contact	after 150k contact	after 200k contact
Resistance (mΩ)	MIN	45.32	60.52	60.45	72.97	100.25
	MAX	78.44	94.87	174.37	188.07	199.34
	AVG	63.03	77.56	87.03	108.96	137.14
	STD	4.62	9.43	13.93	16.89	25.96

Summary

- Elastomer Sockets can be tuned with impedance matching.
- Tuned elastomer sockets can provide longer life cycles with lower and consistent contact resistance.
- Tuned Elastomer Sockets can provide high density and improved signal performance over coaxial pogo sockets.