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Improve Socket Performance by Simulating Embedded Device S-parameter

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Shanghai ▪ October 29, 2019

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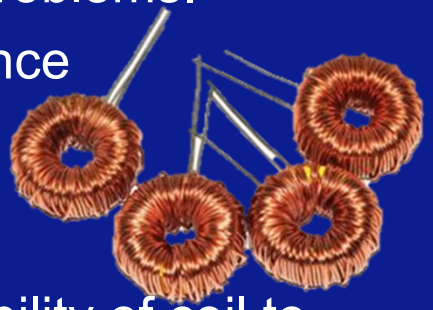
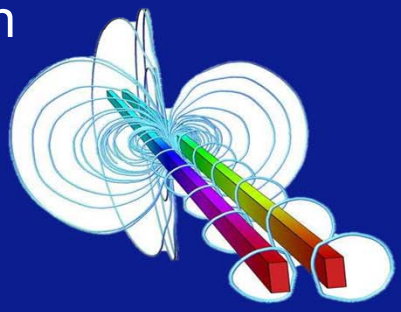
Contents

- Inductors & Inductance
- Derive Spring Pin Inductance
- Different simulation tools comparison
- Case Study – Passive Device
- Improvement of socket design
- Discussion & Future Plan

Inductors & Inductance

- Inductance is a critically important electrical property because it affects all four of the fundamental signal integrity problems.
- In many case, the goal will be to decrease inductance
  - Mutual inductance / Switching noise
  - Loop inductance / Power distribution network
  - Effective inductance of return plans / EMI
- Inductance is a physical quantity to measure the ability of coil to produce electromagnetic induction
- $L = \frac{\varphi}{I}$





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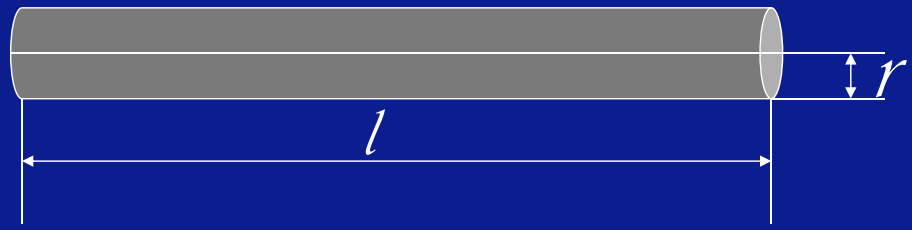
Inductance Extraction

① Formula Calculation



$$L = \frac{u_0 l}{2\pi}\left(ln\frac{2l}{r} - 0.75\right)$$

- L: Inductance
- l : Length of the rod
- r : Radius of the wire
- u_0 : Permeability under vacuum

l= 4.05mm
r= 0.155mm
L=3.193nH

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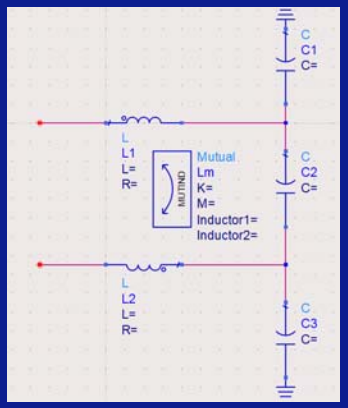
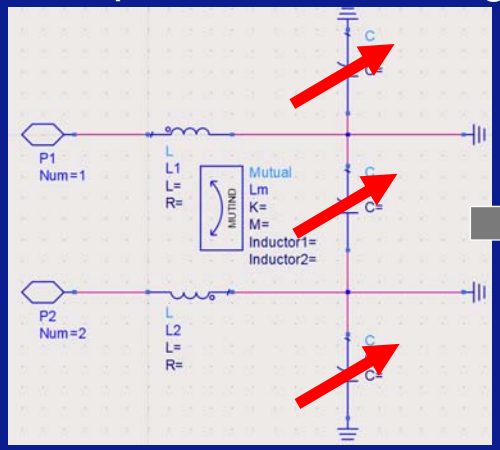
Inductance Extraction

② Full Wave Solver + Circuit Analysis

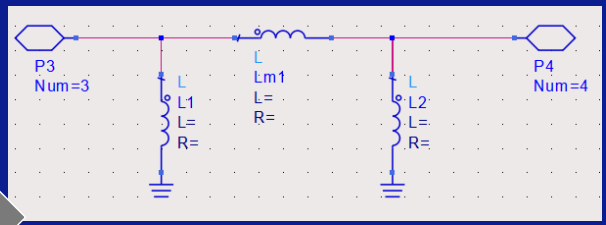
- It is often need to do inductance and capacitance components to complete circuit design during chip design, so it is important to evaluate the value of inductance and capacitance prior to circuit design.



Transmission Line LC Model



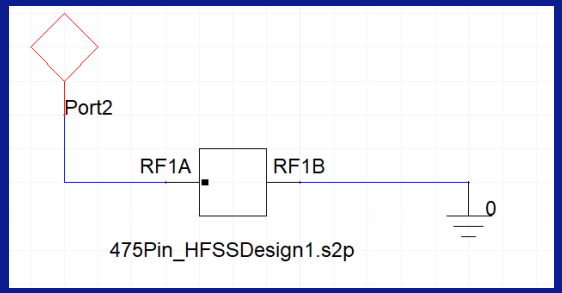
Short Model

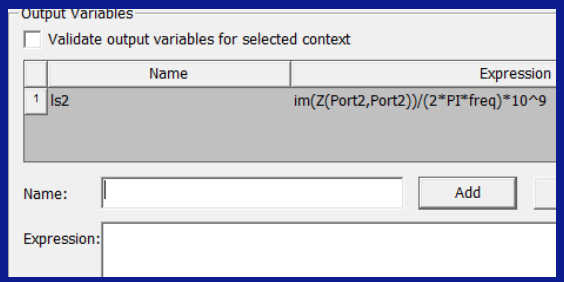


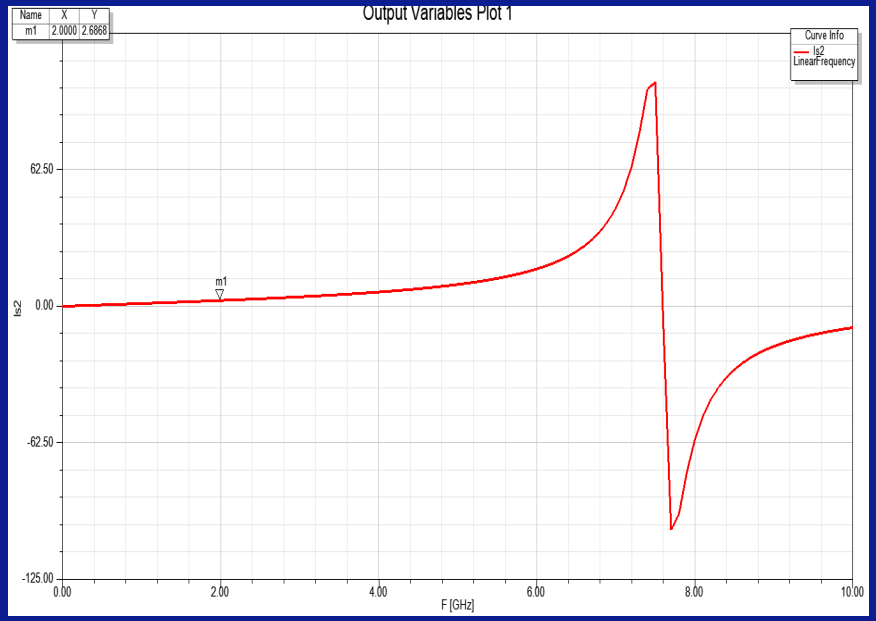
$$L1 = IM(Z(1,1)/(2 * PI * freq)$$
$$L2 = IM(Z(2,2)/(2 * PI * freq)$$
$$Lm = IM(Z(2,1)/(2 * PI * freq)$$

Equal Model

Inductance Extraction







Self Inductance : 2.668nH @ 2GHz

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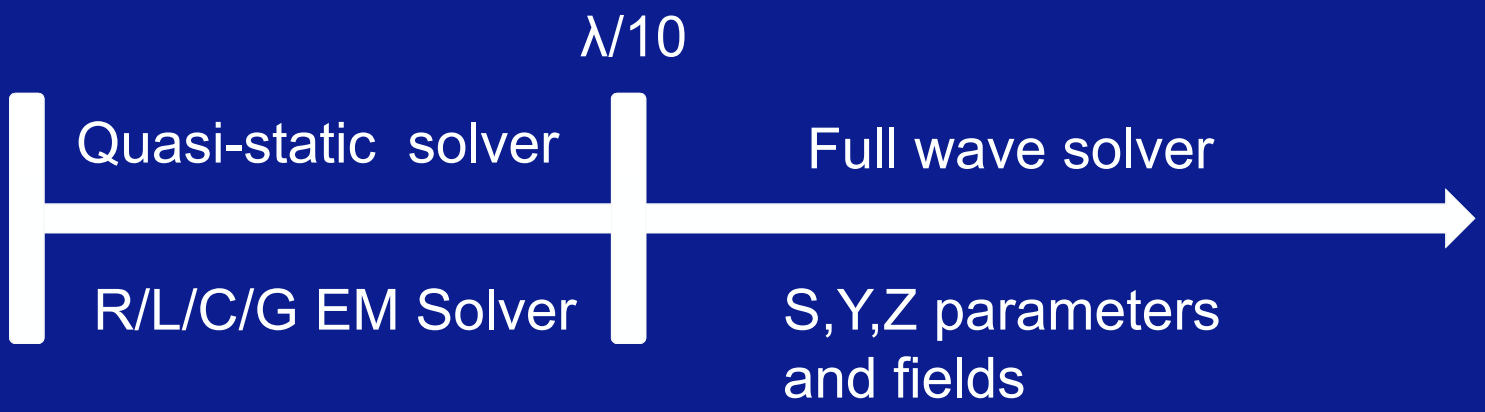
Solver Comparison



EM Solver is easy to extract the data of R/L/C/G, however if the frequency is too high, then Full wave solver will be more suitable.

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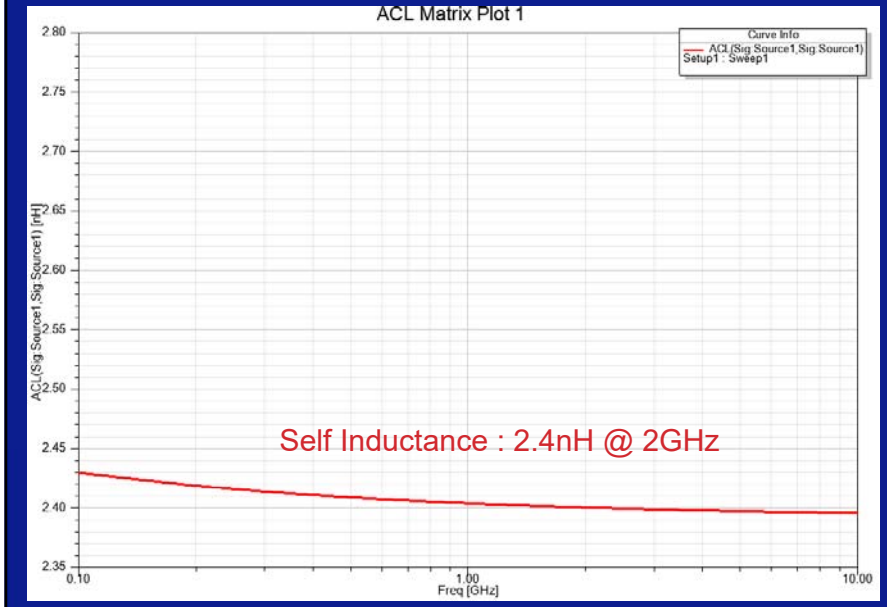
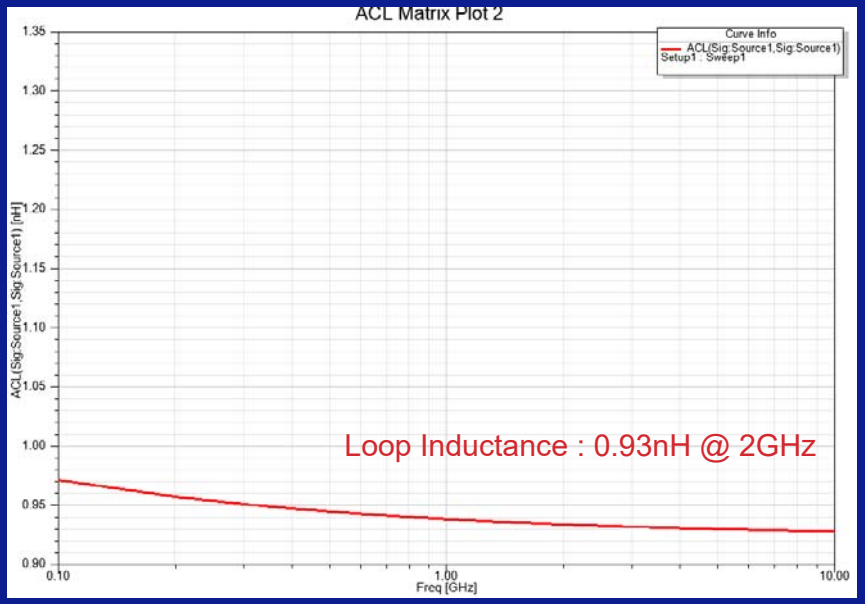
Inductance Extraction

③ EM Solver



Self Inductance



Loop Inductance

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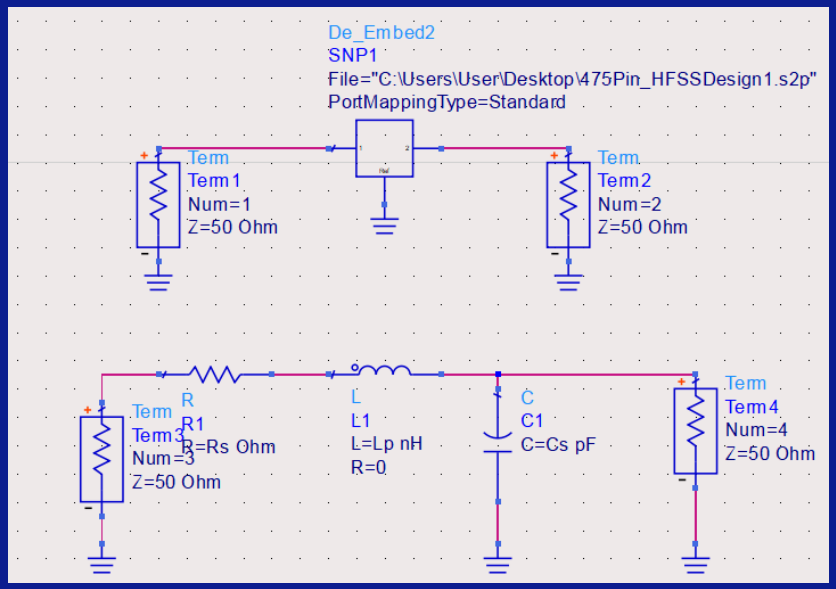
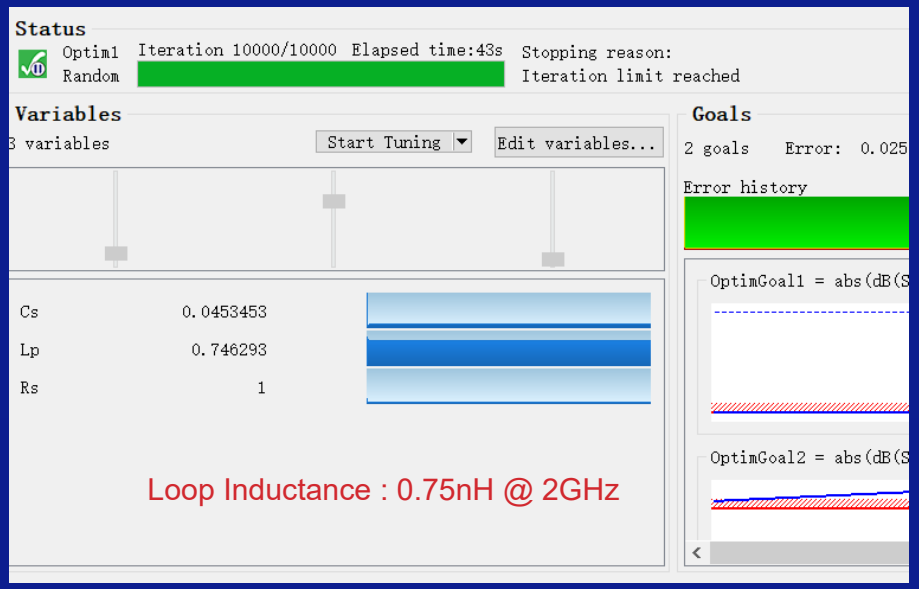
Inductance Extraction

④ Classical Method





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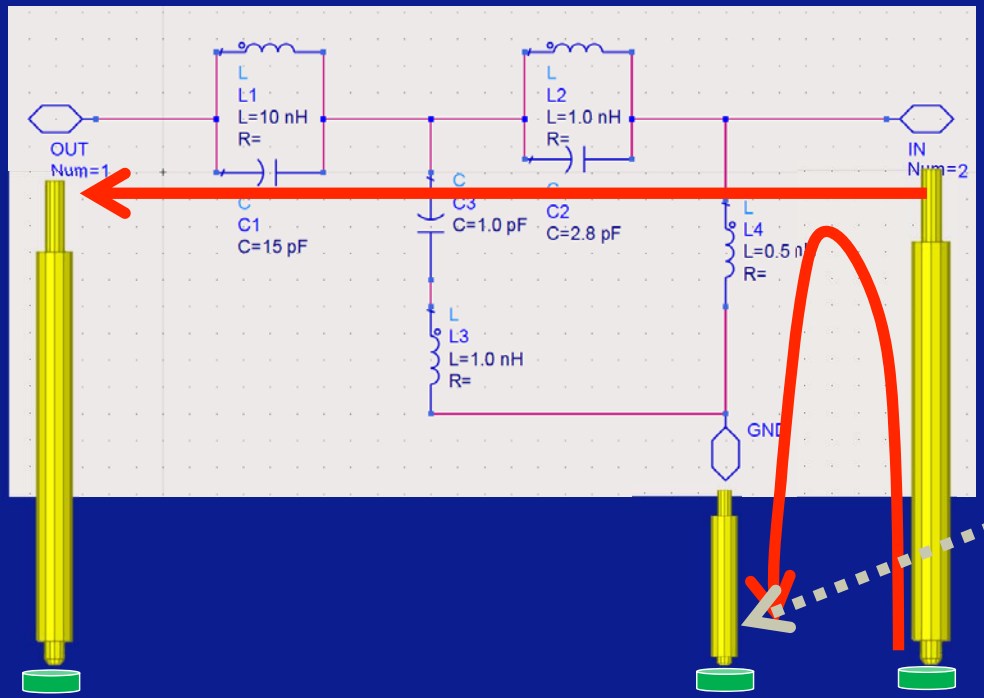
Data Summary

Item	Theory	Self	Loop
1	Formula calculation	3.193nH	
2	Full Wave Solver	2.668nH	
3	EM Solver	2.4nH	0.94nH
4	Classical Optimization		0.75nH

How Inductance Performs



- Grounding pin is extremely sensitive to the inductance
- Filter bandwidth is related to the inductance
- L parasitic is proportional to the length of the pin

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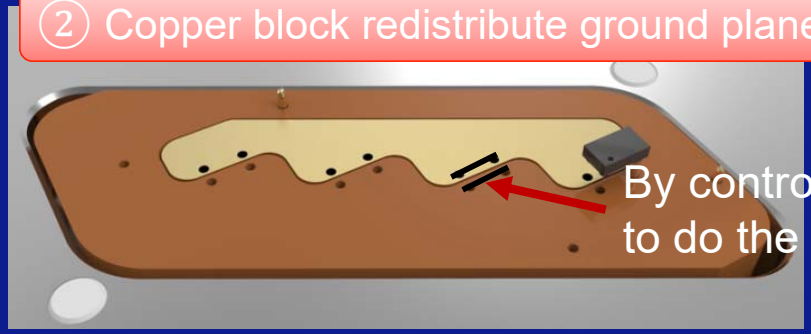
Socket Structure

① Standard Socket

② Copper block redistribute ground plane



→ Socket embedded copper block as grounding plane

By control the distance from pin to the ground plane to do the impedance matching

③ Coaxial Socket

By using coaxial structure to do a matched signal path, to get a low inductance.

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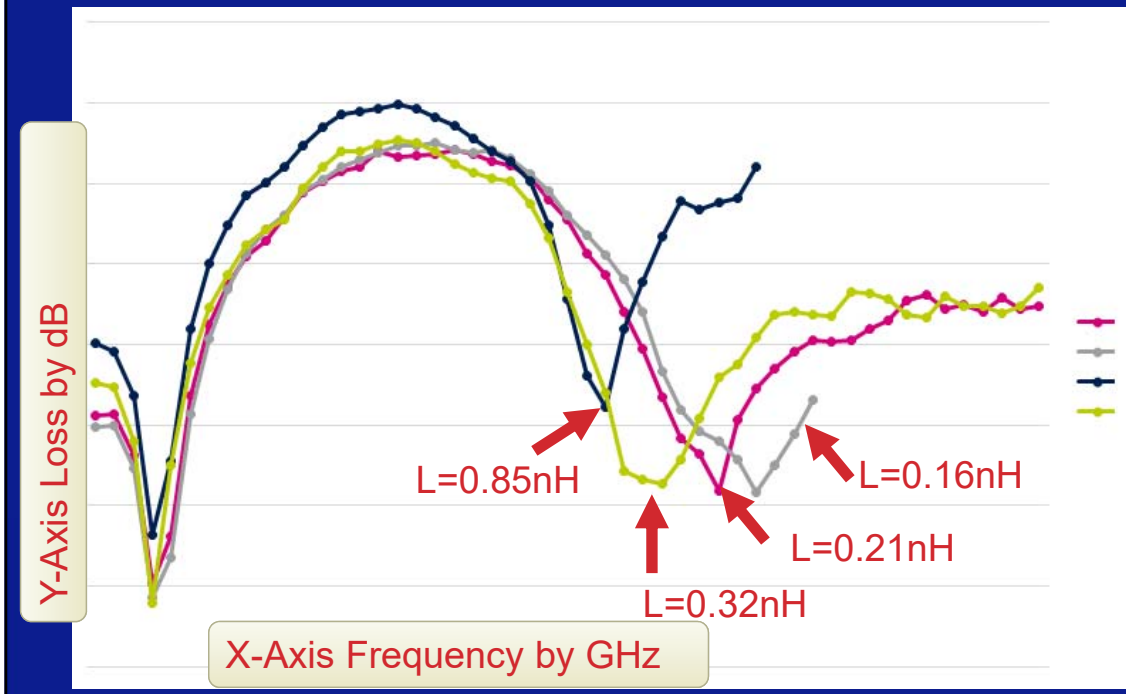
Test Data Comparison



	input_Pin:Source2	RegularPolyhedron5:Source1
Freq: 3 (GHz)		
input_Pin:Source2	2.4534	1.1506
RegularPolyhedron5:Source1	1.1506	1.3808

Copper block lump data by EM Solver

Unknown
Membrane
Long Pin
Short Pin

Inductance data by circuit simulation

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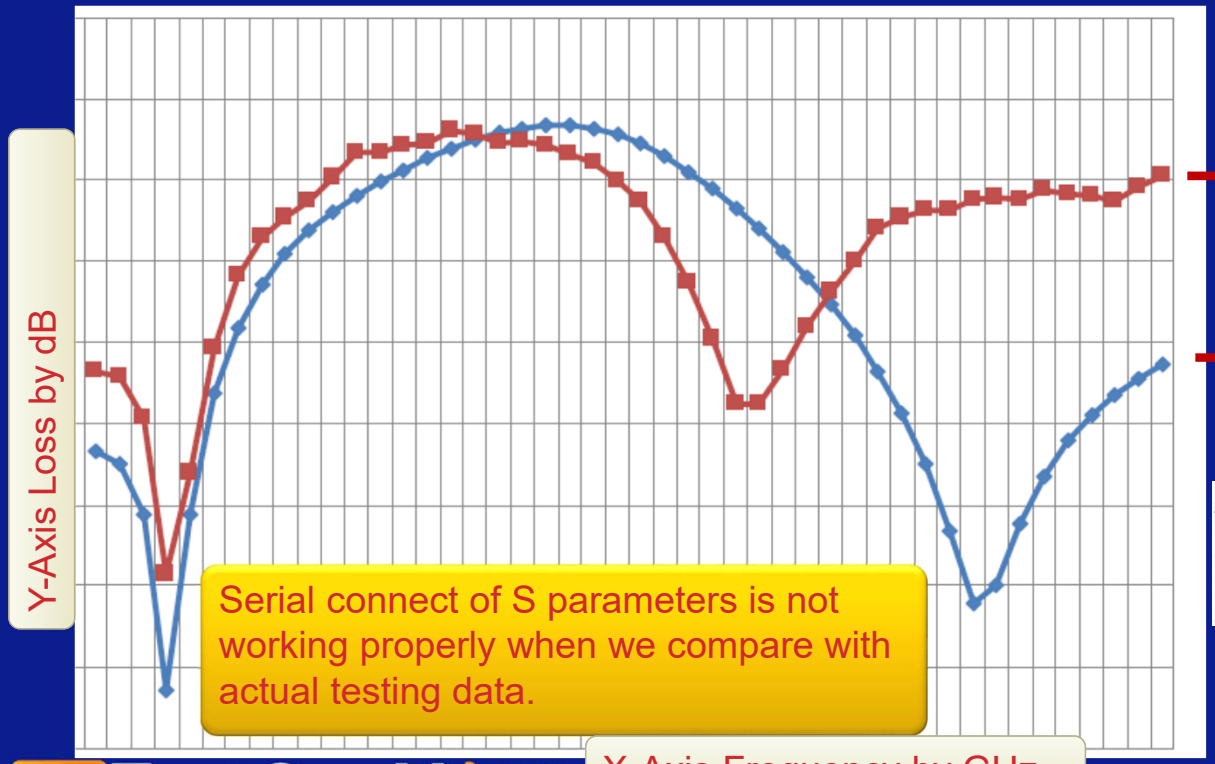
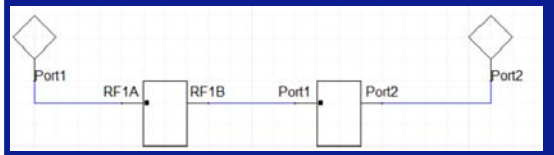
Measurement Vs Simulation



Test Device

Simulation Data



SOCKET CHIP

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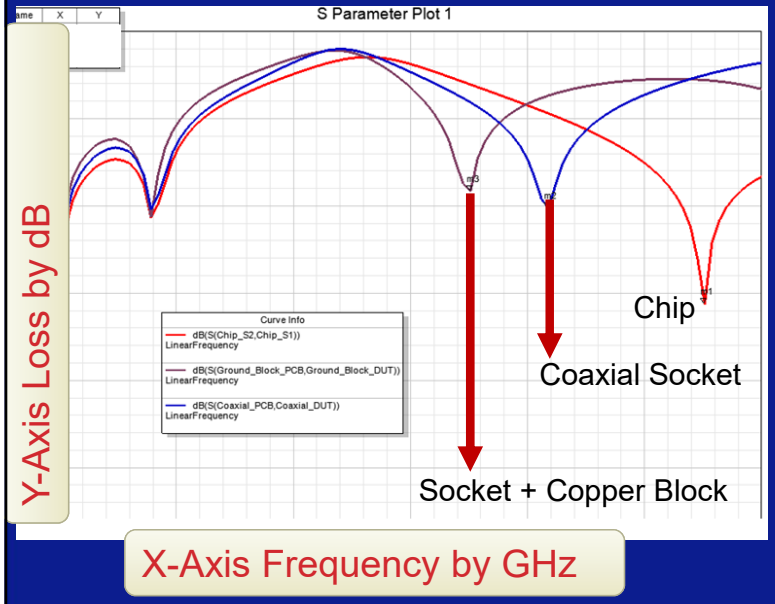
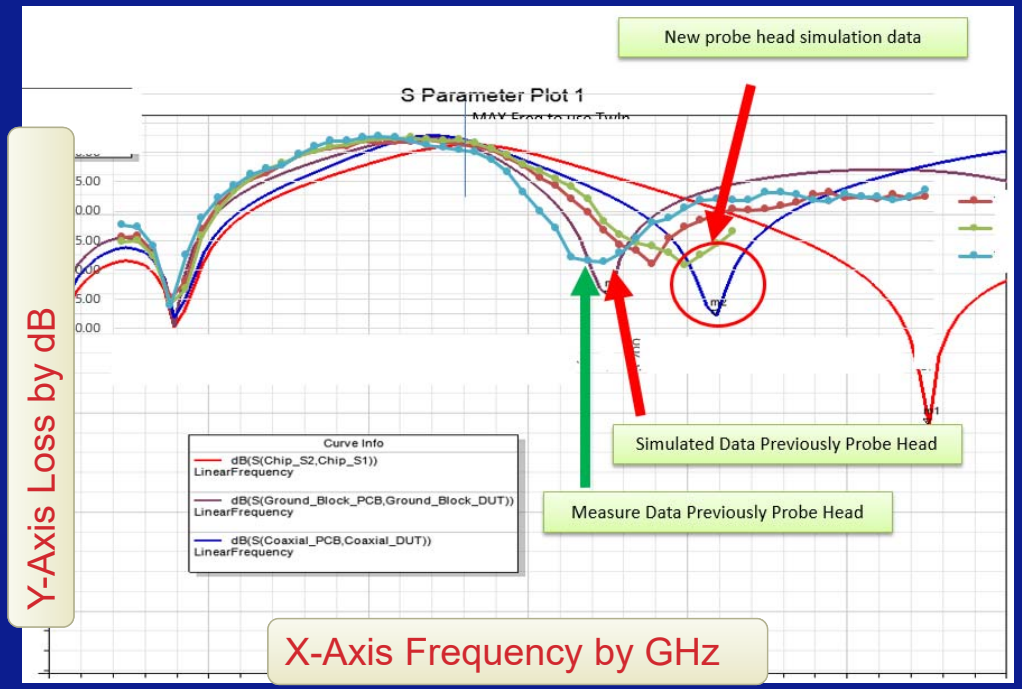
Embedded Chip S-Parameter



Simulated Data Vs Chip S-Parameter



Simulated Data Vs Measurement Data

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Summary & Discussion

- Passive circuitry is more sensitive to the inductance which introduce by the spring pin.
- EM solver is more convenient and easy to get the inductance data of spring pin.
- Embedded the Chip of S-Parameter is more close the actual measurement data, and help for improvement of socket design.

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