
SEVENTEENTH ANNUAL
BiTS
Burn-in & Test Strategies Workshop
March 6 - 9, 2016
Hilton Phoenix / Mesa Hotel
Mesa, Arizona
Archive- Session 4
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BiTS 2016 Burn-in & Test Strategies Workshop

Session 4

Marc Mössinger

Session Chair

BiTS Workshop 2016 Schedule

Performance Day

Tuesday March 8 - 8:00 am

Frequently High

"High Speed BGA Sockets from a System Perspective"

Don Thompson - R&D Altanova

"A Solution of Test, Inspection and Evaluation for Blind Signal Waveform on a Board"

Tatsumi Watabe, Makoto Kawamura, Hiroyuki Yamakoshi - S.E.R. Corporation

"Device Packaging and How It Affects RF Performance"

Noureen Sajid, Jeff Sherry - Johnstech International

"Automotive Radar Test"

Jason Mroczkowski - Xcerra Corporation

BiTS 2016 Burn-in & Test Strategies Workshop

High Speed BGA Sockets from a System Perspective

Don Thompson
Mauricio Aguilar Salas
R&D Altanova

2016 BiTS Workshop
March 6 - 9, 2016

Our Perspective on Sockets

- R&D Altanova does over 300 turn key load board & probe card designs a year
- Many designs required simulations to meet performance targets
- Sockets were supplied by another vendor 95% of the time
- ***Sockets constantly cause signal integrity (SI) and power integrity (PI) problems in our designs!***

The Historically BGA Socket Story

- BGA Sockets use spring pins
  - Fantastic compliance
  - Good contact performance
  - Reasonably low cost
- Typical new development for spring pins has focused on DC contact performance
  - Plating
  - Wear patterns
  - Cleaning cycles

A Typical Socket Customer

- Sockets are purchased by a different group within the customer's organization than the group specifying load boards
- Typically test engineers don't have any control over socket definition
- Corporate's focus for sockets is usually touchdown reliability, reparability, and cost
- *This leaves a performance gap for designs where Signal Integrity and Power Integrity concerns are not considered*

Interesting Metrics to Compare

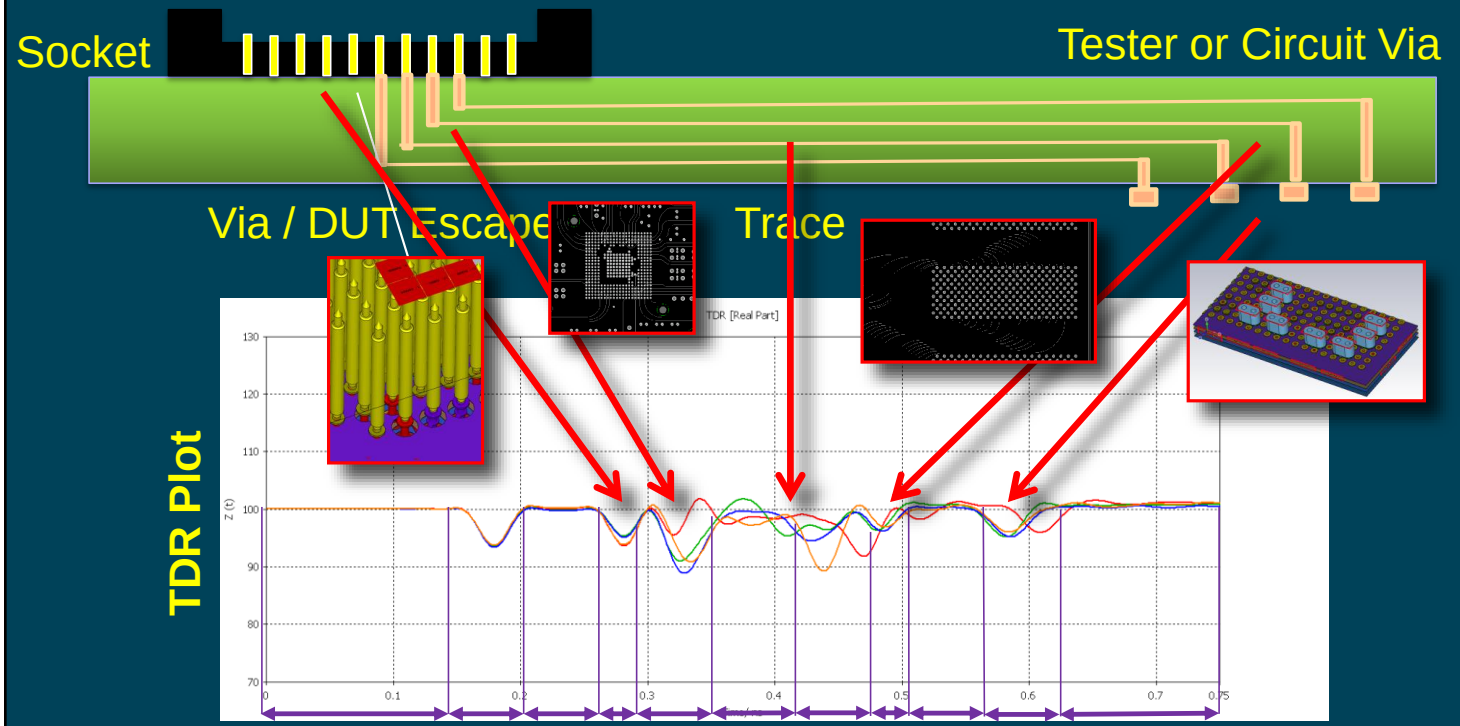
- Signal Integrity *(Also known as bandwidth or impedance)*
- Power Integrity *(Pin Inductance)*

<u>Other things to consider</u>

- Cycle life
- Cost
- Current Carrying capacity (CCC)
- Compliance

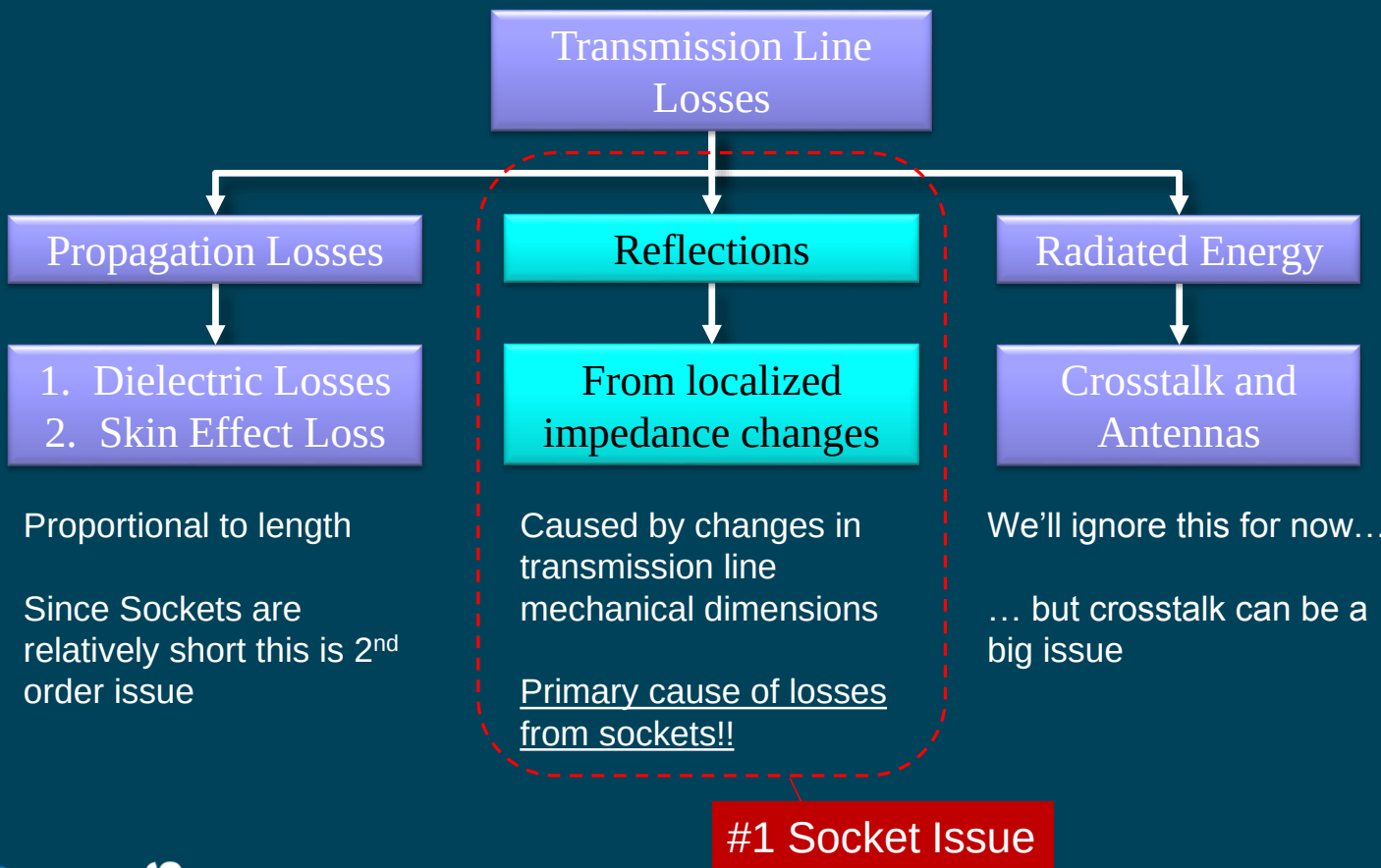
Simulating a Generic Load Board

- The board is modeled and simulated using different tools and combined for complete path modeling
- The customer's concern is always on the whole path!

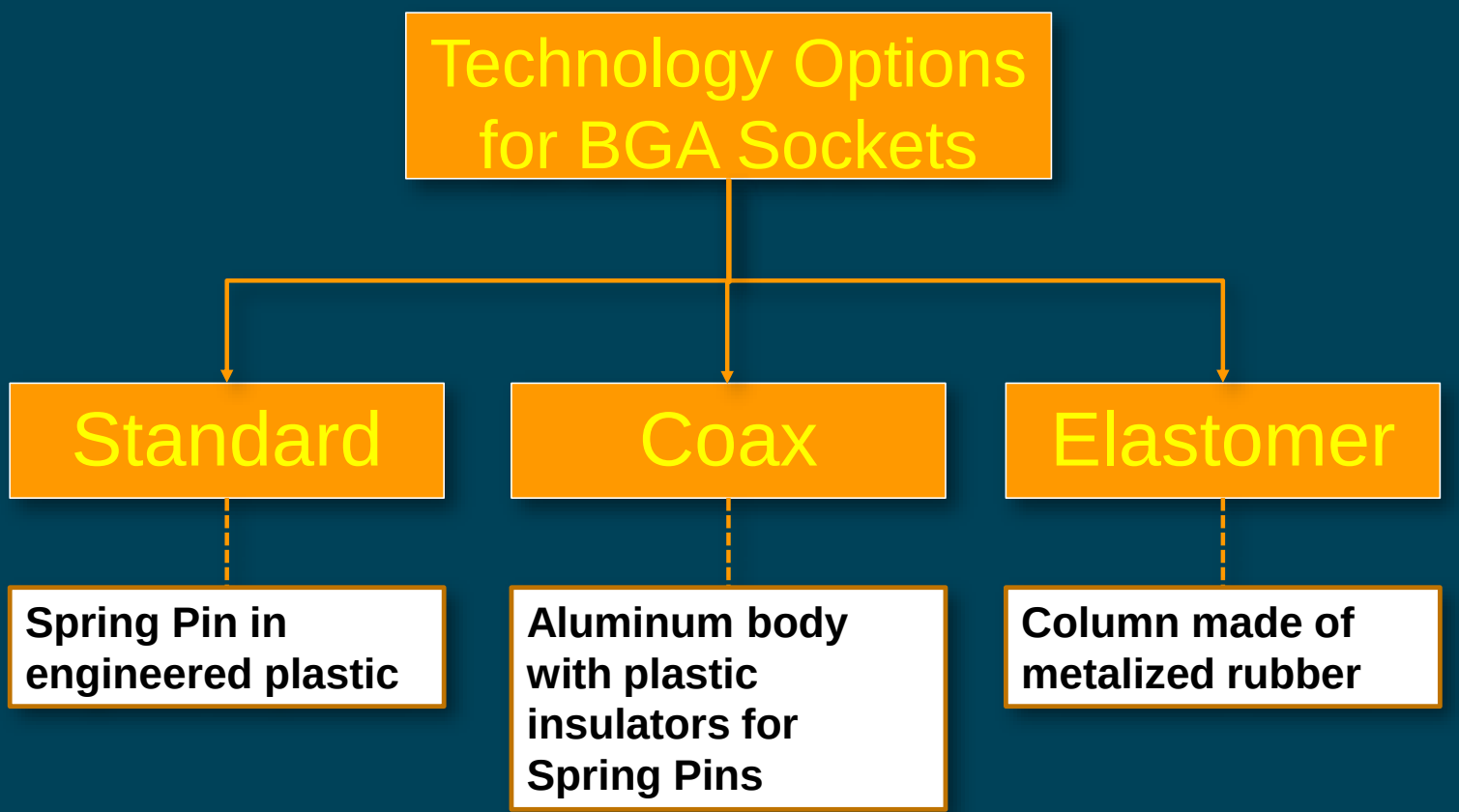


Signal Integrity Review

(We'll talk about Power Integrity later!)

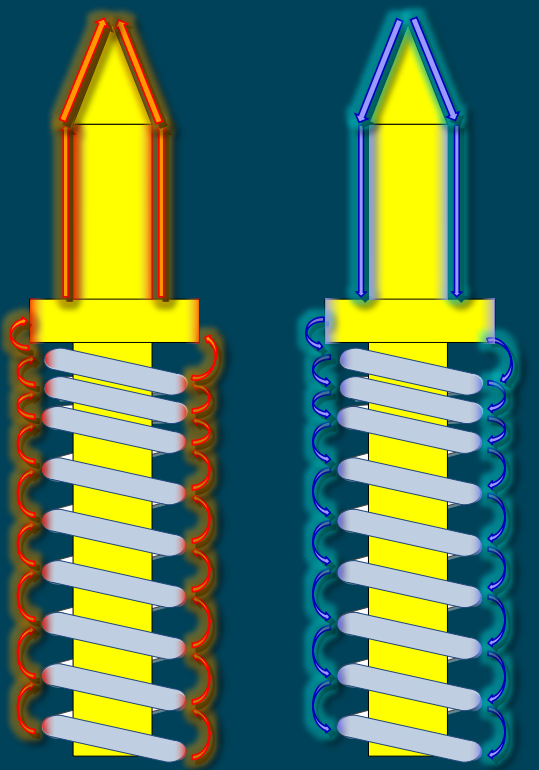


BGA Socket Options



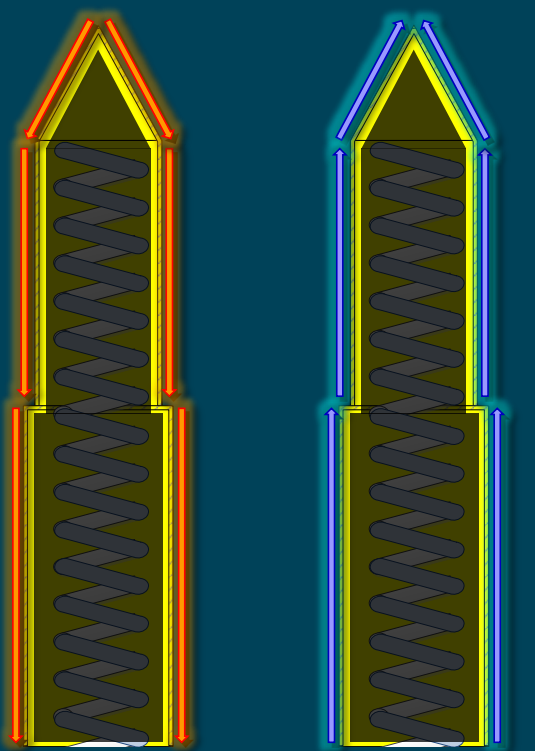
What Am I Ignoring and Why? Stamped Pins

- Ignoring Stamped Spring Pins
  - A stamped pin typically exposes the spring to the high speed signal energy
  - Depending on the frequency the signal, HF current will either flow through the spring causing higher inductance or jump spring coils reducing performance



SI of a Standard Spring Pin

- Versus a standard spring pin:
  - In a standard pin, the spring is hidden from the high speed signal, due to skin effect, creating a better performing transmission line
  - The standard spring pin is ideal from an SI perspective



In a spring pin, the HF energy flows entirely in the outer shell completely avoiding the spring

Review: Generic Load Board Performance

- Impedance control is the primary impact a socket has on the signal path
- Crosstalk is also a secondary concern which is very important for DDR and PCIE signal groups
- Dielectric loss and skin effect loss for the socket are not significant impacts on the channel (ignore them!)

Socket Impedance

"Standard"

- Not Impedance controlled
- Typically very capacitive

….but standard sockets can be impedance controlled

Coax

- Impedance controlled by design

Elastomer

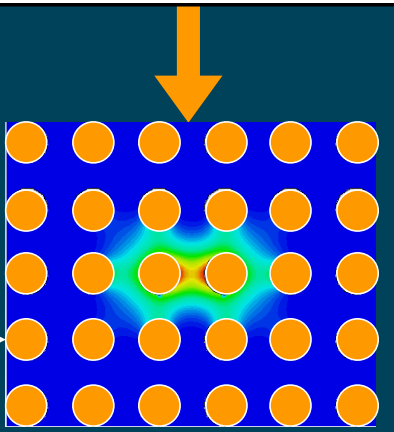
- Not Impedance controlled

But so short it's negligible!

With a short interconnect you can not impedance control the impedance <u>but it is so short it doesn't matter</u>!

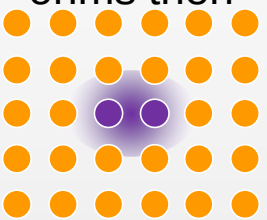
Pin diameter can be adjusted until target impedance is met

For example, 100 ohm differential shown here



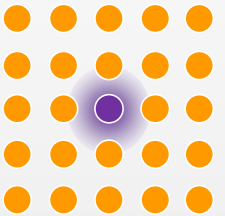
*See "***A High Bandwidth Socket Solution for SERDES applications on ATE Load Boards" BiTS 2014 by Don Thompson for more info on socket impedance tuning***

However… If this is 100 ohms then

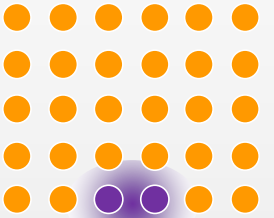


OK

This is NOT 50 ohms



And this is NOT 100 ohms



You **can not** create uniform design "standard" socket that is impedance controlled for different impedance configurations (e.g. Diff, SE, edge, corner, etc)

Socket SI Summary

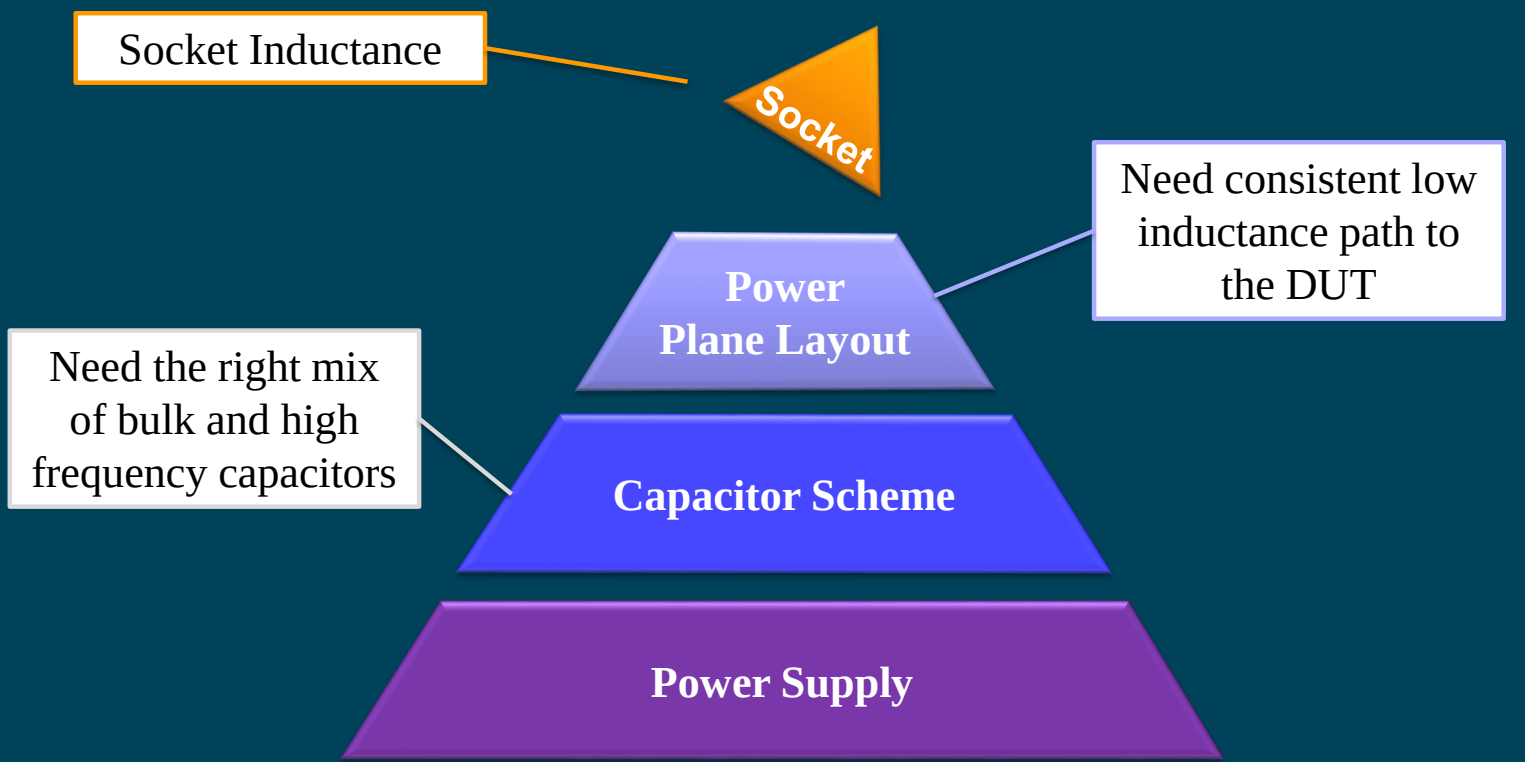
Good
(If impedance tuned, bad if not)

Better
(All Signals Impedance Controlled)

Best
(Proven on 80 GHz Socket)

Power Integrity

Pieces of Power Integrity



Power Integrity Goals

- Current swings on the Device Under Test (DUT) must not lead to voltage swings on the power rail that cause power rail driven test failures
- Capacitance values are selected to cover the power supply current and frequency requirements, and we must design the PCB and socket to minimize degradation of this solution

Concept of Modeling

Modeling Tradeoff Example: MLC Capacitor

0.1uf

$Z = 1/(SC)$ or $1/(j\omega C)$

0.1uf

C ESR ESL

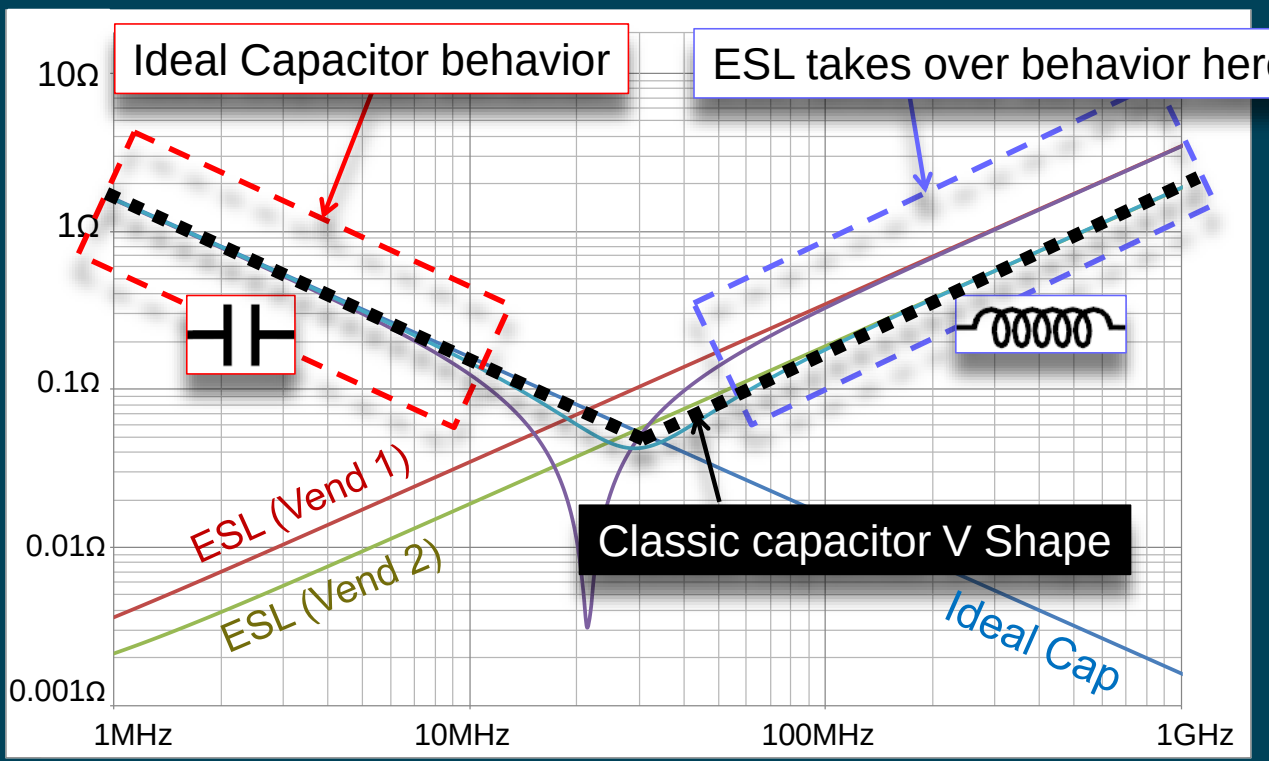
$$Z = \frac{S^2 + S(R/L) + 1/(LC)}{S/L}$$

Vendor 1	0.1uf	3mΩ	550pH	$Z(j\omega) = j\omega^2 - j/(LC) + \omega(R/L)$
Vendor 2	0.1uf	42mΩ	300pH	

ESL – Parasitic Inductance
ESR – Parasitic Resistance

Generic Capacitor Model

Comparing two vendor's capacitor impedance:



Capacitor Rules of Thumb

DC | 10kHz | 100kHz | 1MHz | 10MHz | 100MHz

Power Supply

Bulk Caps (1 kHz – 1 MHz)

Mid Tier (500 kHz – 10 MHz)

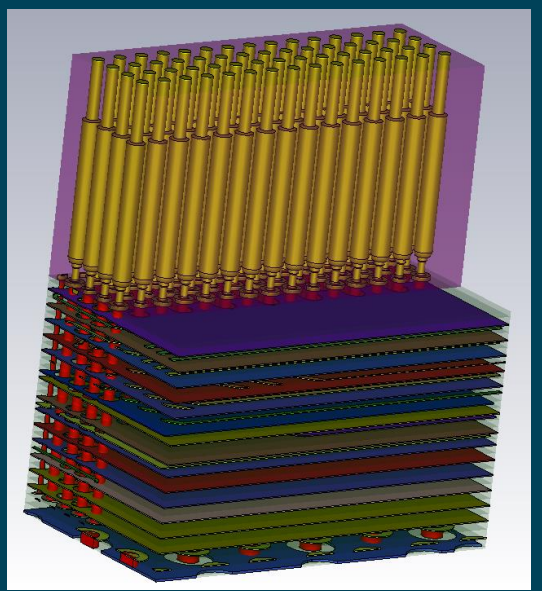
HF Caps (1 MHz – 25 MHz)

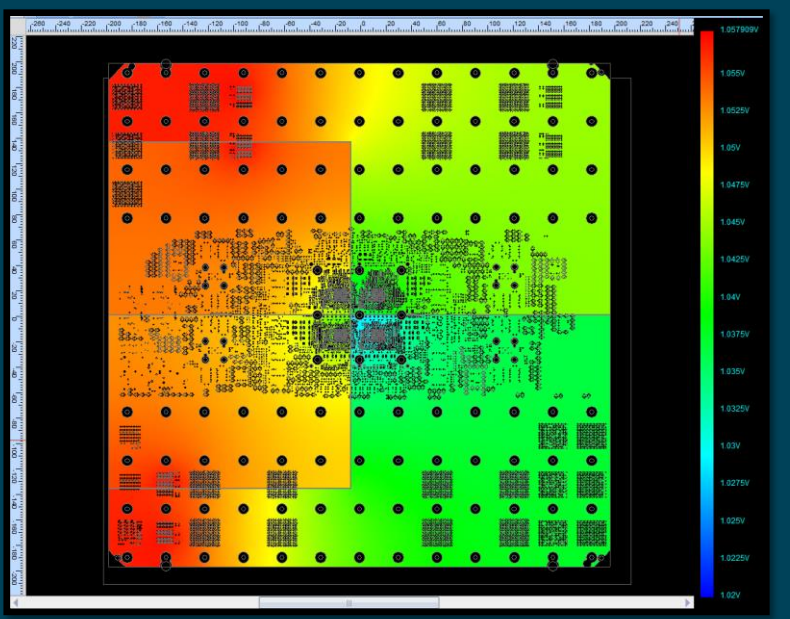
Bandwidth limited due to vias

HF Caps w/no Via Inductance (1 to 100+ MHz)

Socket matters here!

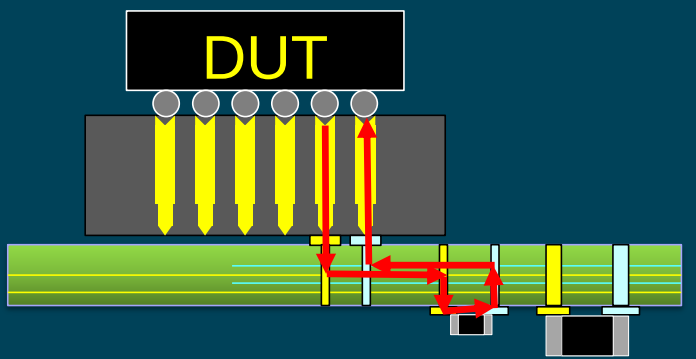
Load Board Power-Integrity Analysis





Simulation takes into account all aspects of the board design, including capacitor models, power planes routing, and socket performance

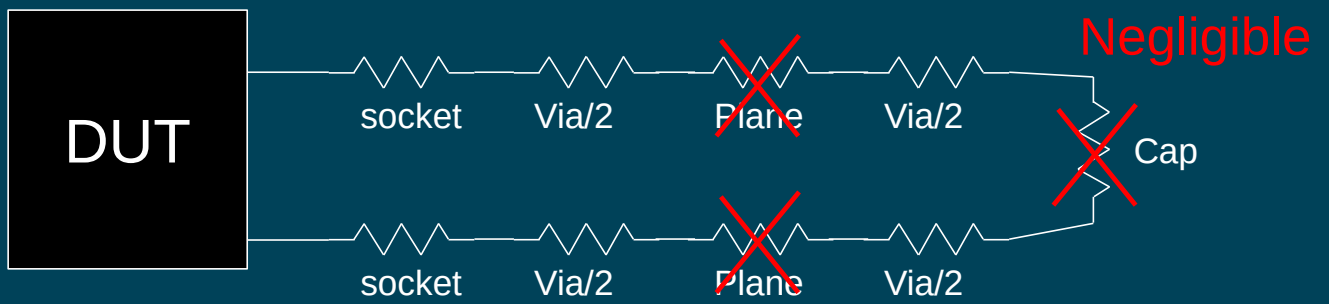
Frequency Domain View

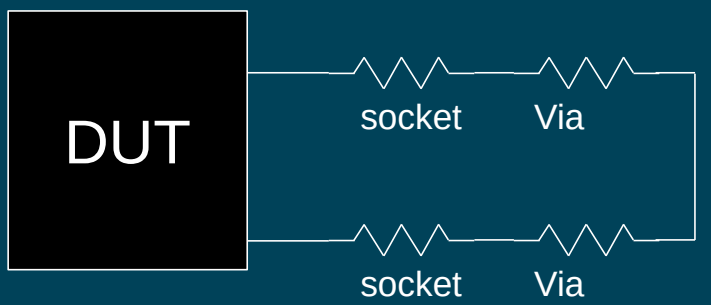


- High Frequency PI performance comes from the path from DUT to capacitor and back
- This determines the capacitor's ability to "help" the DUT with PI
- The inductance of the path looks like resistance at frequency
- The higher the path inductance, the higher the resistance at frequency

HF DUT Impedance Path

HF DUT Impedance Path





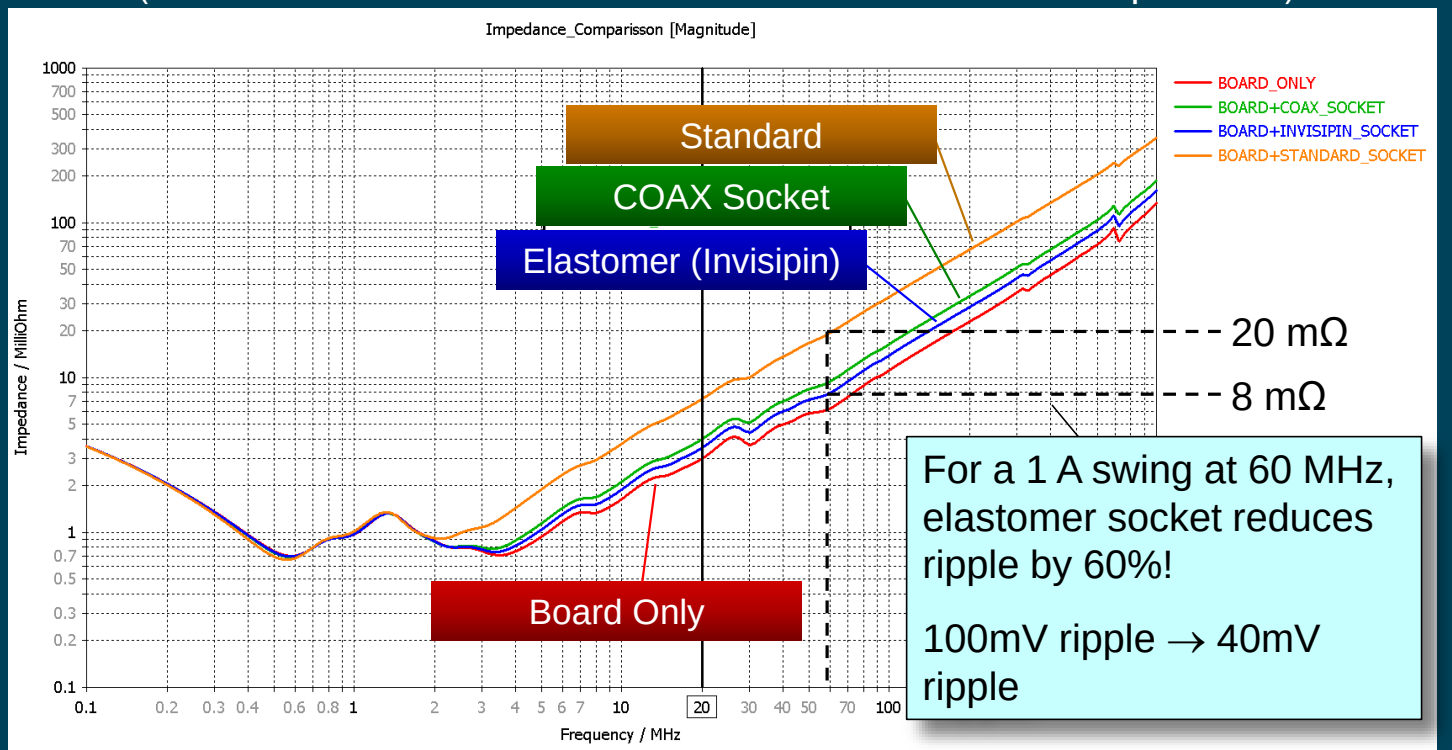
- Via and Socket Inductance dominate the high frequency response
- Reducing the inductance of these two pieces will dramatically improve high frequency PI performance!
- There are tricks to reduce via inductance… but what about sockets?

Socket Power Integrity

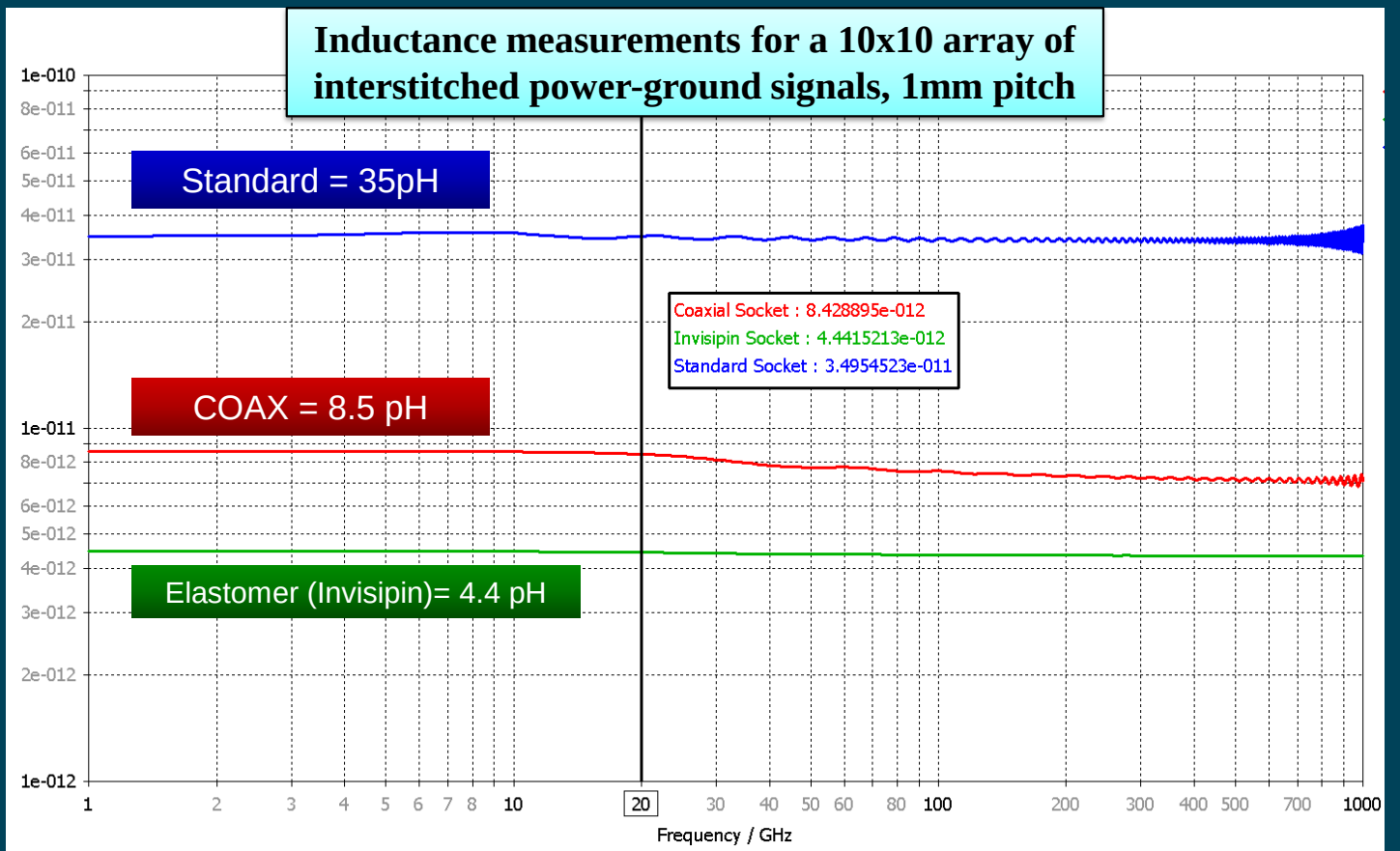
"Standard"	Coax	Elastomer
		
• The baseline performance	• Because of the tight coupling between power and ground (body) the inductance is much lower	• Inductance is proportional to length, so the ultra short height of elastomers makes this solution have very low inductance

Adding Sockets to Real Board Analysis

(This is a standard board with no "tricks" to reduce via impedance)



Socket Inductance Values



Summary and Conclusion

- Be aware of socket performance and how it effects your design and pick the socket that works for your application!

	Standard	Coax	Elastomer
Cost	5	3	4
Bandwidth	2	4	5
Crosstalk	1	4	4
Power Integrity	2	4	5
CCC	4	5	3
Compliance	5	5	2
Cycle Life	5	5	3