Return Loss Measurement Consensus Group Meetings Summary

Liav Ben-Artsi

Marvell Technology Group

Supporters

- Zivny, Pavel - tektronix
- Lusted, Kent - Intel
- Ran, Adee – Intel
- Moore, Charles – Avago Technologies

Consensus Group

- Calls were conducted for return loss measurement / de-embedding discussion.
- 27 individuals Participated in the call(s): Thanks for participating: Albert Vareljian, Kochuparambil Beth, Myles Kimmitt, Matt Brown, Richard Mellitz, Mike Dudek, Mike Gilsdorf, Mohammad Kermani , Tom Palkert, Adee Ran , Galen Fromm, Magesh Valliappan, Mark Bugg, Yonatan Malkiman, Michael Brownell, Charles Moore; John Ewen; Kavi; Scott Irwin; Shanbhag Megha; Vittal Balasubramanian; Pavel Zivny; Rick Lutz; Walter Katz; Mike Li, Adam Healey, Liav Ben-Artsi
- Discussed the problems that arise when measuring return loss through a fixture.
- Discussed possible measurement reference planes (the edge of a fixture, at the device ball)
- Discussed the need / justification of de-embedding to the device pins and defining the return loss @ the device pins.
- Gathered ideas and data to come up with a remedy.

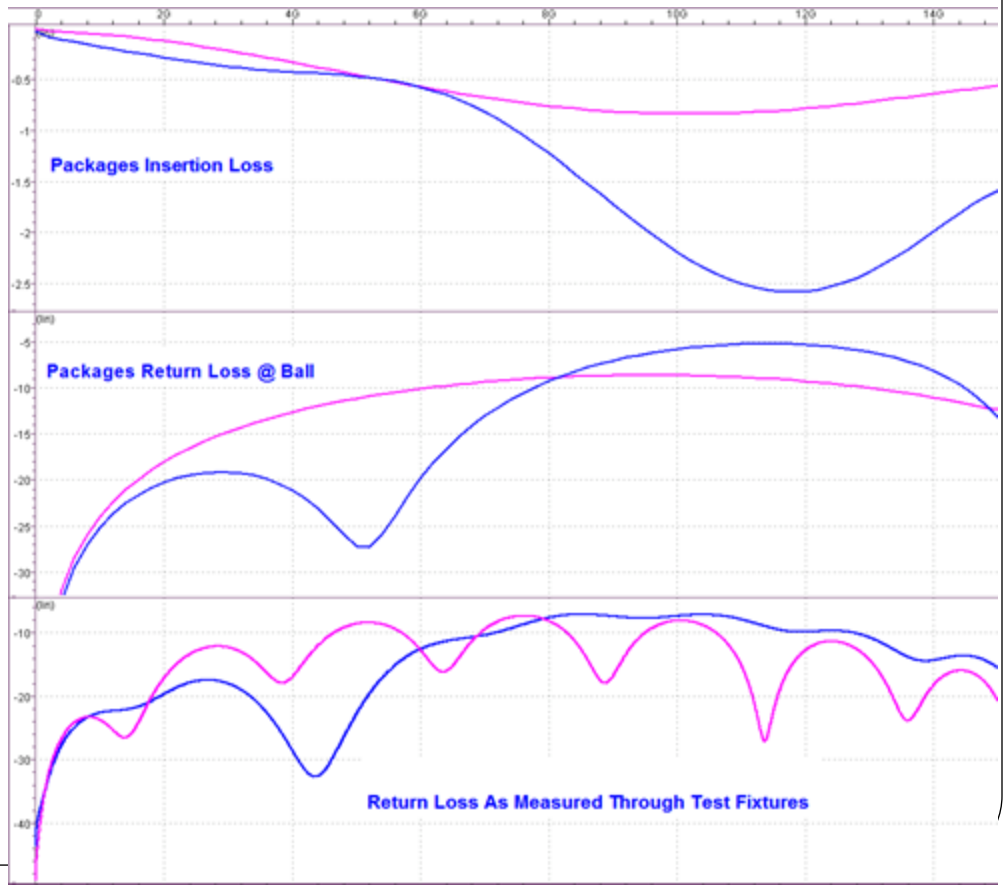
Return Loss Measurement Challenge

- There may be a lot of device break-out via types varying in return loss measurement impact.
- It was shown that fixture can obfuscate return loss measurement.

Difference between two packages cannot be distinguished

- It is extremely easy to demonstrate how two very different packages' behaviors measurements are masked by test fixture tolerance.
- May require chip over-design (to meet specific fixture RL) or allow qualifying a problematic chip RL if fixture is good enough…

	Blue	Purple
IL (max)	2.6dB	0.84dB
RL @ ball (max)	-5.1dB	-8.6dB
RL through Fixture (max)	-7.1dB	-7.31dB



Comment #166

Cl **93** *SC* **93.8.1.1** *P* **156** *L* **51** # 166

Comment Type **T** *Comment Status* **X**

Measuring through an interconnect as defined in 93.8.1.1 can obfuscate real chip return loss measurement.

SuggestedRemedy

Redefine fixture definition to improve the fixture quality by defining:
1. Better return loss (-15dB up to 13GHz)
2. Defining fixture ILD (|ILD|<1dB)
3. Fixture IL up to 1.6dB

It is taken into account that fixture may not be feasible in multi lane device. In this case it is required that the actual fixture be "de-embedding worthy".
In this case the real fixture will be de-embedded and the defined fixture embedded.
(Presentation to be supplied)

Proposed Response *Response Status* **O**

Comments #349 & #350

Cl **93** *SC* **93.8.2.1** *P* **162** *L* **26** # 349

Comment Type **TR** *Comment Status* **X**

Measuring the receiver return loss through an interconnectcan obfuscate real chip return loss

SuggestedRemedy

Redefine fixture return loss according to presentation

Proposed Response *Response Status* **O**

Cl **94** *SC* **94.3.11.1.1** *P* **188** *L* **20** # 350

Comment Type **TR** *Comment Status* **X**

100GBase-KP4 test fixture definition is TBD

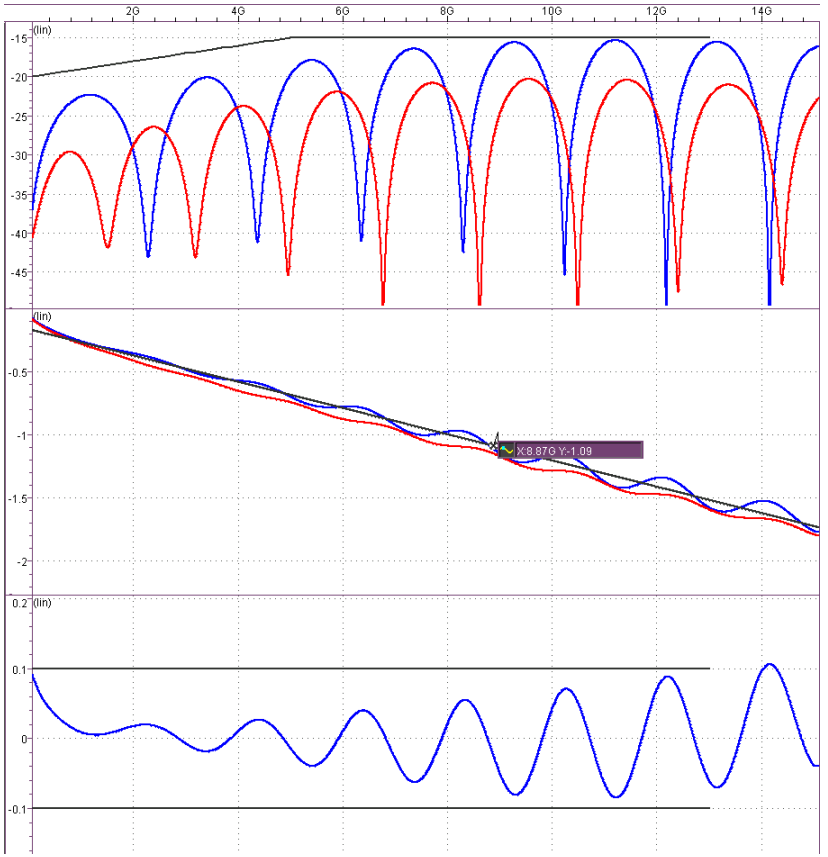
SuggestedRemedy

Define test fixture equations according to presentation (IL, ILD and return loss)

Proposed Response *Response Status* **O**

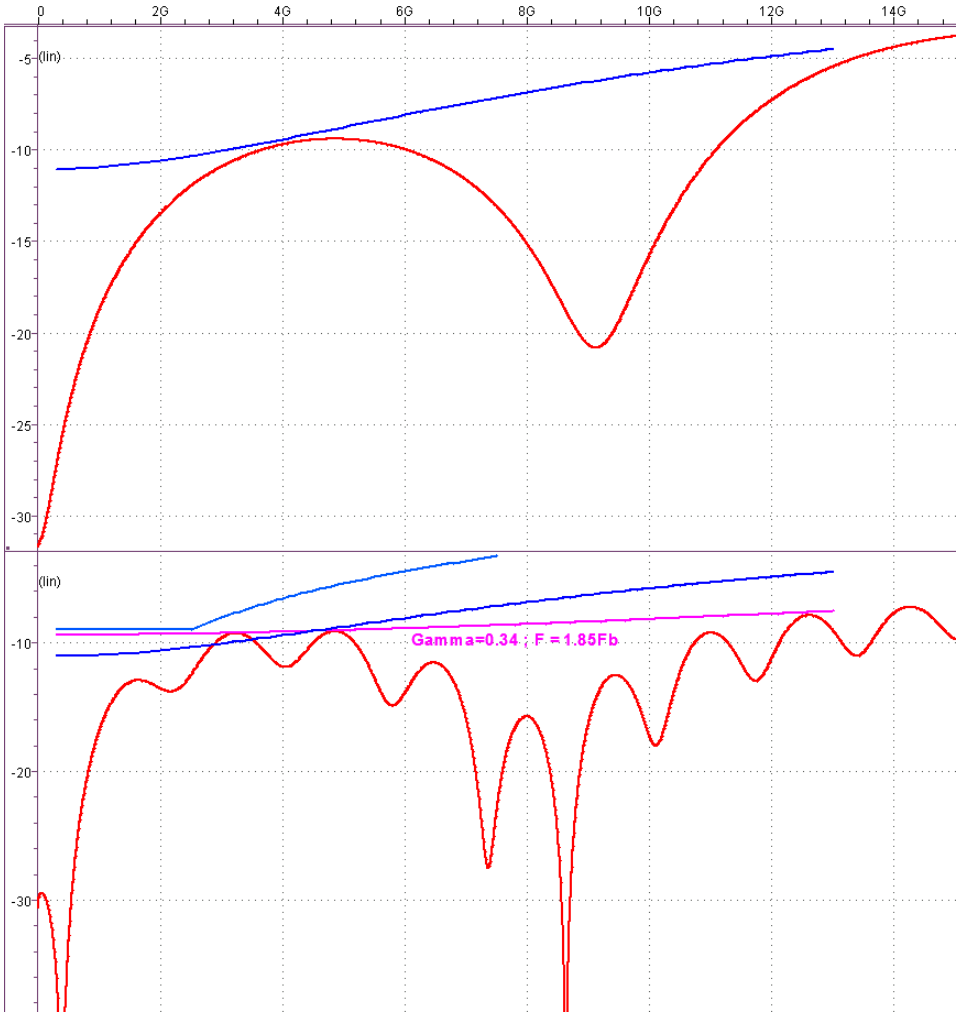
Recommended Fixture Limits

- Return loss ≥ 20dB @ 10MHz with slope up to 15dB @5GHz
  Return loss ≥ 15dB @ 5GHz ≤ frequency ≤ 13GHz (10G for KP4)
- 1.2dB ≤ Insertion loss ≤ 1.6dB @ Fb/2
- |ILD|≤0.1dB up to 13GHz
  - Correlates to:
    - Long via (~80mil)
    - ~10mil stub
    - Optimized Anti-pad
    - Removed un-used pads
  - F1=1G ; F2=Fb/2 for ILD calculation .



Fixture Influence On Measured Return Loss

- Measured return loss limit:
  - Gamma = 0.34
  - F=1.85Fb
    (Correlates to Li (0.28 ,0.77Fb) @ ball)
- Low frequency updated upward to allow multi-reflection between chip and interconnect.
- High frequency updated downward to account for fixture loss.



Conclusion / Recommendation

- Measuring return loss through test fixture requires a high quality test fixture in order not to obfuscate package return loss.
  - Recommendation: Tighten the fixture definition.
- The return loss limit should take into account multiple reflections that occur between die, ball and test fixture.
- The measured return loss should take into account the fixture insertion loss and return loss (reference to backup slides).
- It is recognized that the new fixture definition may not be feasible throughout all the lanes in a multi-lane device case. The fixture definition is not intended to specify the allowed break-out characteristics as it incorporates tight limitations (tight trace impedance limitations, via construction limitations, etc.).

Next Steps / Follow up

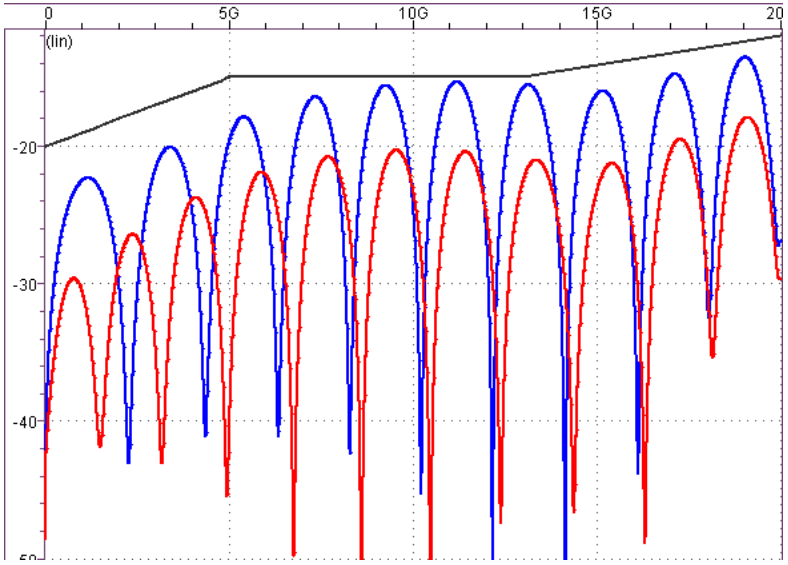
- For fixtures that do not meet the definition:
  - Define what is allowed to be de-embedded and what is allowed to be embedded instead.

Thank you

Backup slides

What happens beyond 13G?

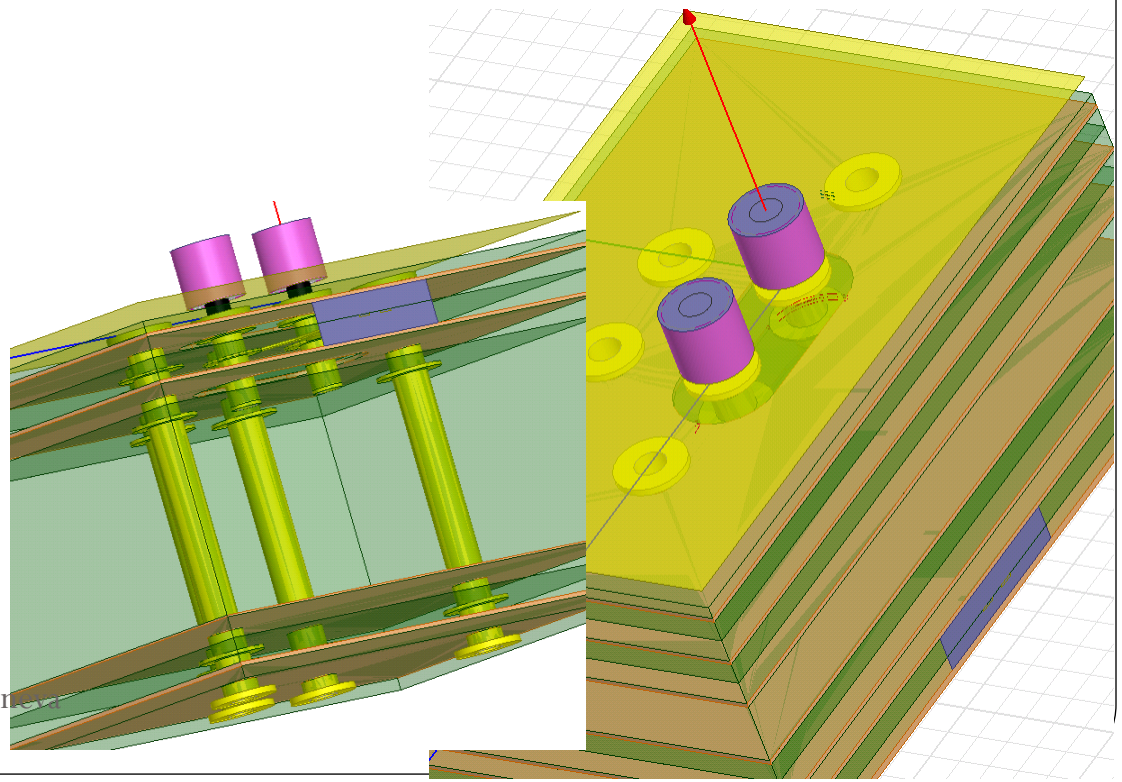
- A Comment was received regarding the fixture definition beyond 13G (after the last consensus group call).
- Add a slope up to the third harmonic of Fb/4?
- Ret loss slope from 15 @ 13GHz to 12 @ 20GHz



How Measuring Through Fixture Can Obfuscate Chip Return Loss

Examined Test Fixtures

- "Light" vias with minimal if any internal pads and stubs.
  - Long via + 4mil stub connected to u-via.
  - Short via, min stub connected to a long via with min stub.
  - µvia ➔ trace ➔ µvia.
  - 5% trace manufacturing tolerance
  - No SMA discontinuity

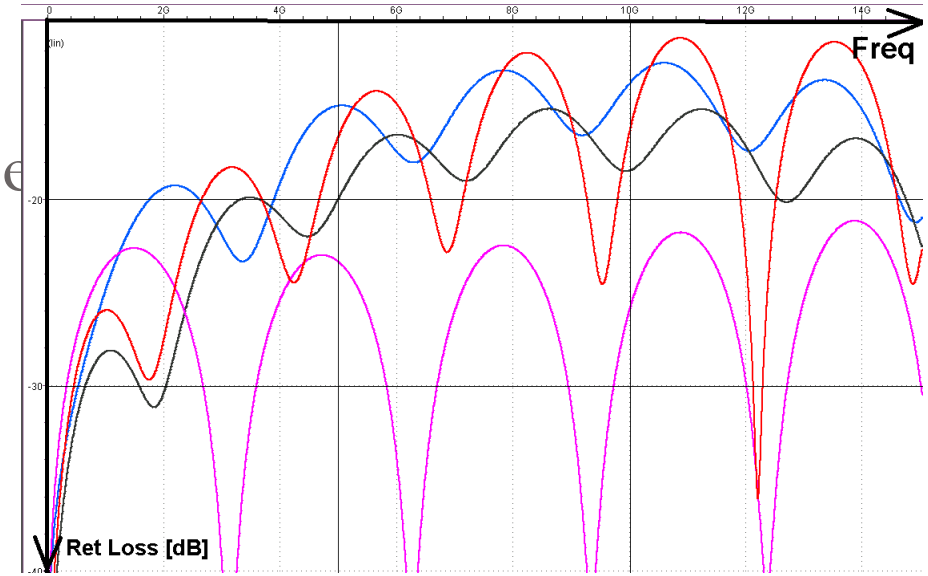


Test Fixtures Return Loss Variance

- Long via, 4 mil stub ➔ trace impedance tolerance ➔ u-via.
- Short via + minimal stub ➔ trace ➔ long via + minimal stub
- µ-via ➔ trace ➔ µ-via

Conclusion:

Real world variance cause the fixture return loss to vary and may obfuscate the real return loss of a chip



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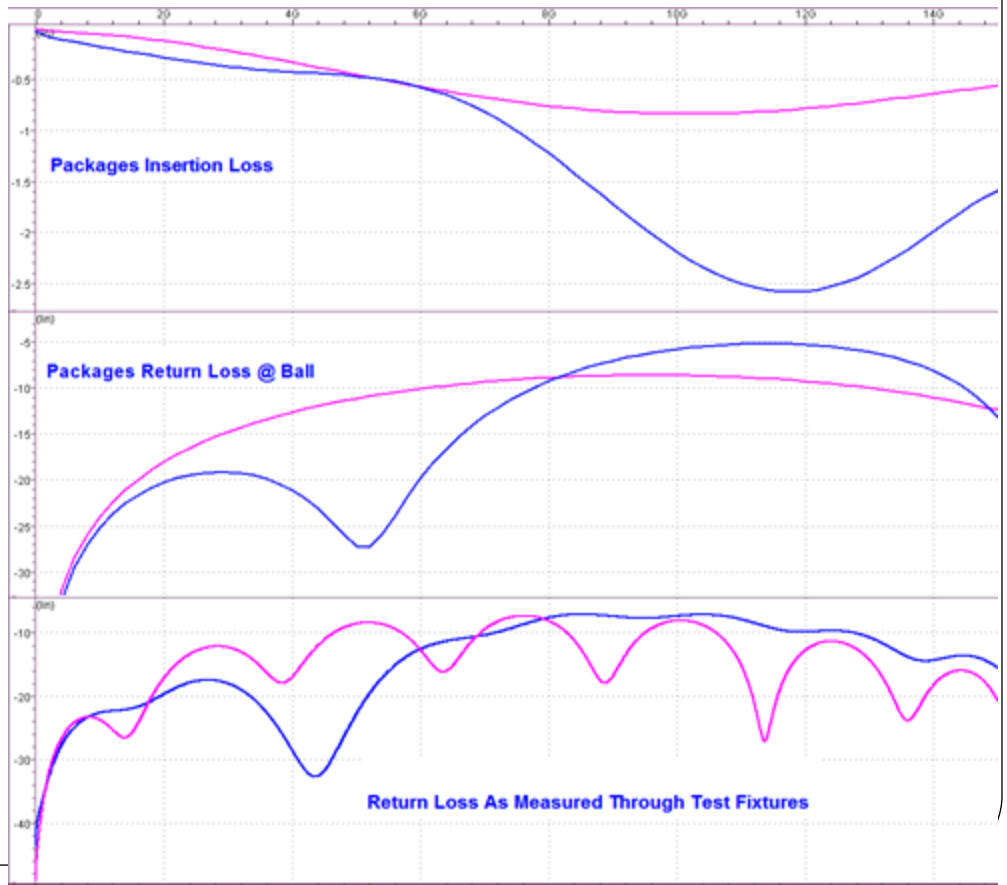
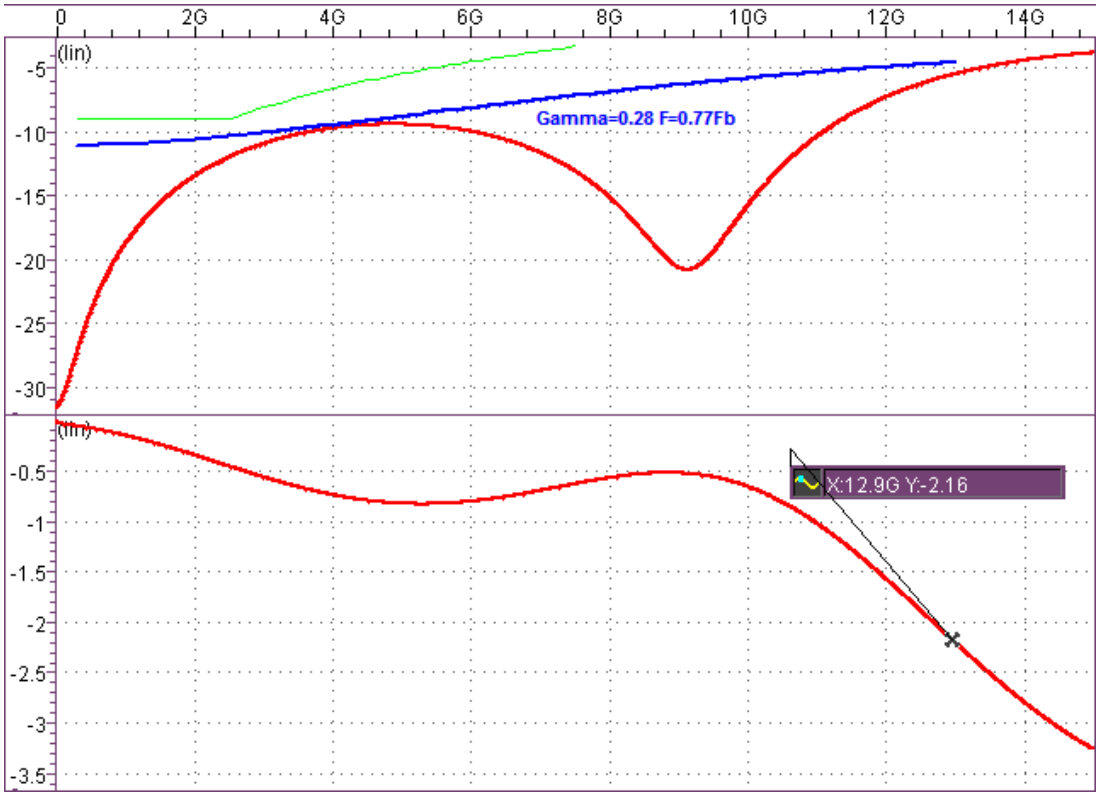


The Influence of The Recommended Fixture on Measured Return Loss

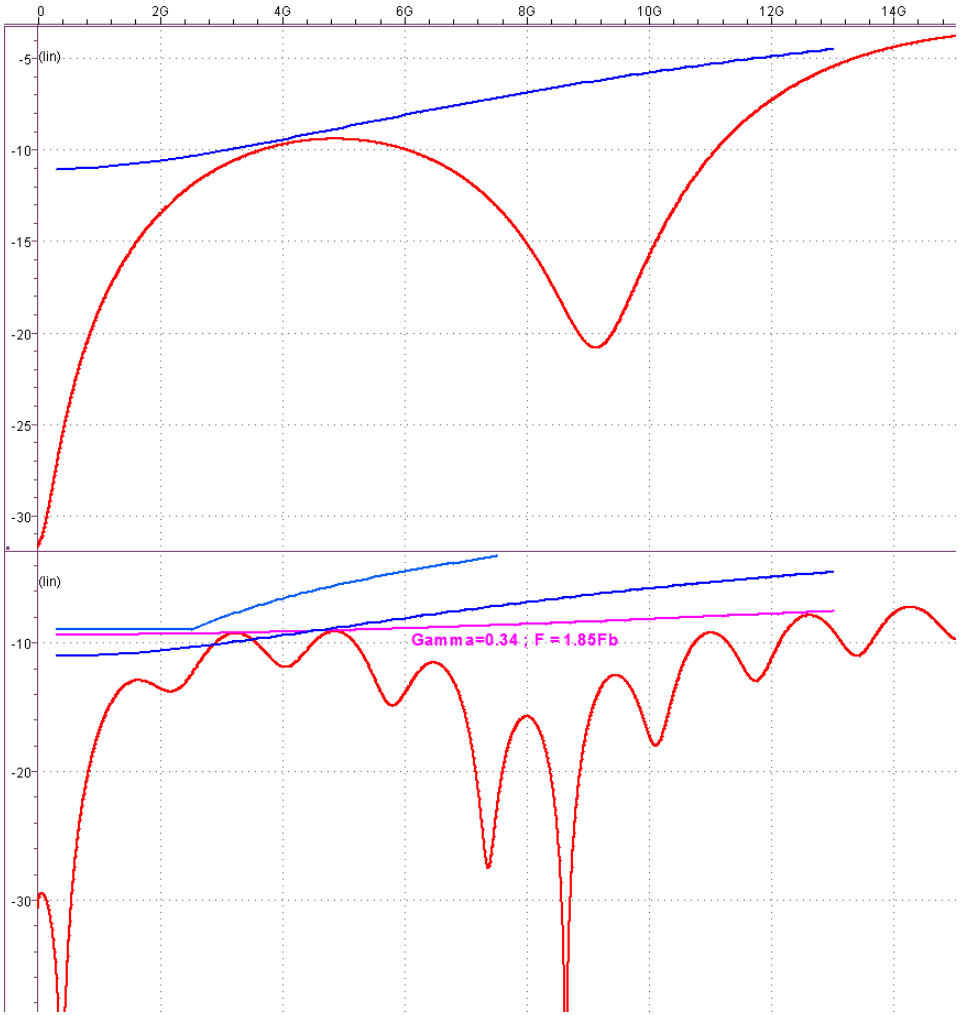
Package Return Loss Case #1

- Examine the return loss of the following package:
- Package designed to have:
  - Return loss meets: Li (0.28 ,0.77Fb)
  - Loss @Fb/2 <2.5dB



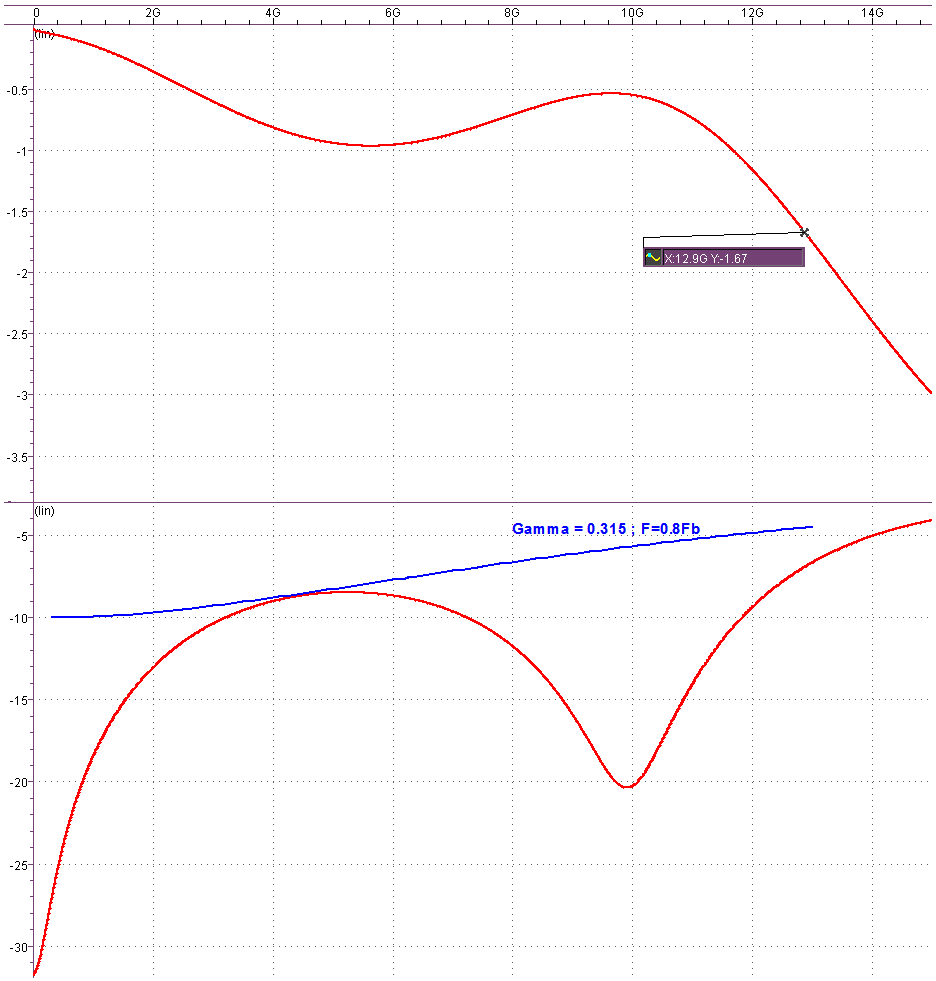
Package return Loss Case1 – Cont.

- Suggested measured return loss limit:
  - Gamma = 0.34
  - F=1.85Fb
- Low frequency updated upward to allow multi-reflection between chip and interconnect.
- High frequency updated downward to account for fixture loss.
- Still below 10GBase-KR limit – Light blue



Package Return Loss Case #2

- Examine the return loss of the following package:
- Package designed to have:
  - Return loss meets: Li (0.315 ,0.8Fb)
  - Loss @Fb/2 <2.5dB (easy to get lower loss @ Fb/2)



Package Return Loss Case 2 – Cont.

- Suggested Measured return loss limit:
  - Gamma = 0.34
  - F=1.85Fb
- Low frequency updated upward to allow multi-reflection between chip and interconnect.
- High frequency updated downward to account for fixture loss.