# Harmonizing Singlemode Connection Return Loss Specification

Vipul Bhatt

400 Gb/s Ethernet Study Group
July 2013, Geneva

# Supporters

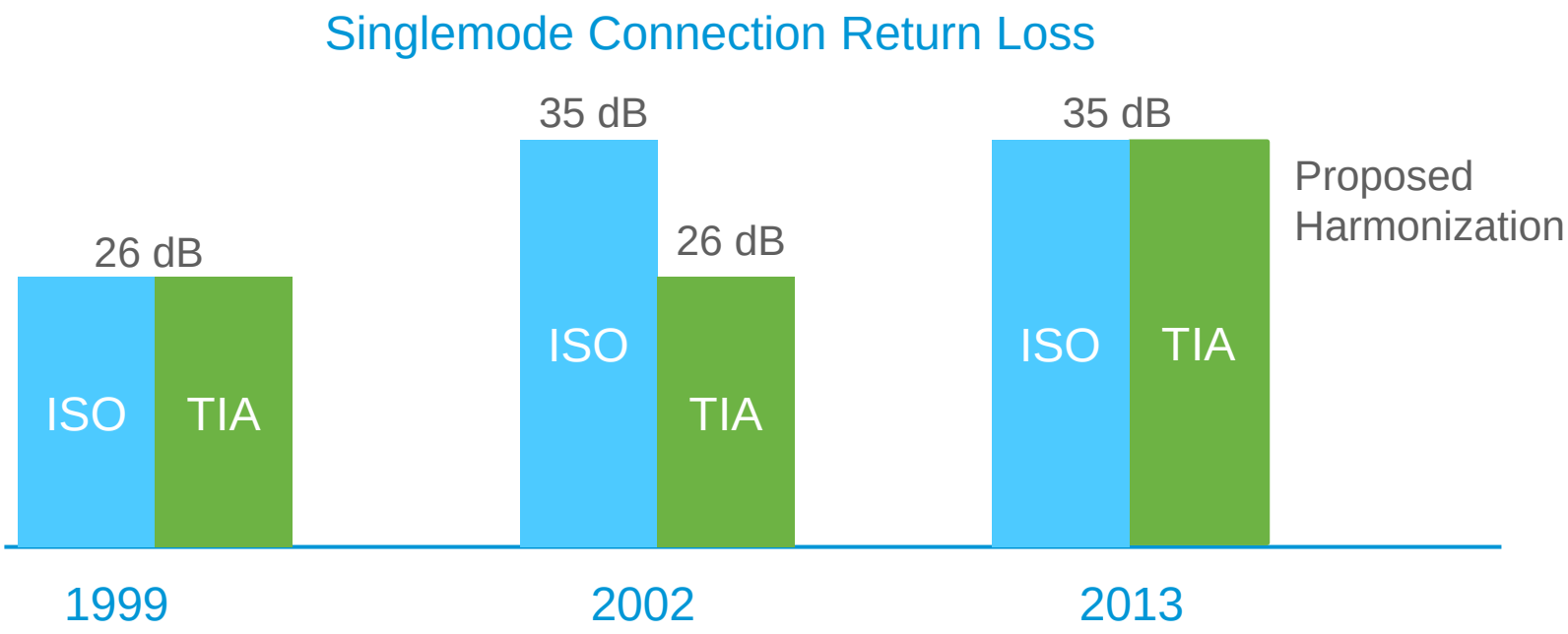
- Sudeep Bhoja, Inphi
- Will Bliss, Broadcom
- Wael Diab, Broadcom
- Mike Dudek, QLogic
- Arash Farhood, Cortina
- Alan Flatman, LAN Technologies
- Howard Frazier, Broadcom
- Ali Ghiasi, Broadcom
- Mike Gilmore, e-Ready Building
- Harold Kamisugi, Sumitomo
- Paul Kolesar, Commscope
- David Lewis, JDSU
- Beck Mason, JDSU
- Gary Nicholl, Cisco
- Mark Nowell, Cisco
- Vasu Parthasarathy, Broadcom
- Rick Pimpinella, Panduit
- Scott Powell, Clariphy
- Rick Rabinovich, Alcatel-Lucent
- Song Shang, Semtech
- Daniel Stevens, Fujitsu Semiconductor
- Steve Swanson, Corning
- Norm Swenson, Clariphy
- Tomoo Takahara, Fujitsu Laboratories
- Toshiki Tanaka, Fujitsu Laboratories
- Alan Tipper, Semtech
- Brian Welch, Luxtera

# Executive Summary

- Since the days of 1 Gb/s Ethernet, the IEEE cabling infrastructure specs have specified the Return Loss value of 26 dB for singlemode connections, consistent with TIA-568 specs.
- Meanwhile, international standard ISO/IEC 11801 spec has been upgraded to 35 dB since 2002. For harmonization, EN 50173-1 adopted 35 dB as well, in 2002.
- For 400 Gb/s and higher Ethernet rates, MPI Noise will be a key performance impairment caused by Return Loss, and a value of 26 dB will add complexity to PMD specs.
- Therefore, it is prudent for us to take the initiative of recommending to the TIA that the SM connector RL spec be harmonized with the ISO/IEC spec of 35 dB, and with what is being deployed in the field today.

# Singlemode Connection RL: Prevailing Standards

- In IEEE optical link specs, we can choose an appropriate value of connection return loss. For optical cable and connectors, we generally point to prevailing major international standards.
- The two relevant standards bodies are TIA-568 (for USA) and ISO/IEC 11801 (for all countries). They are largely equivalent, but this presentation points out one spec on which harmonization has become necessary:



# Harmonize TIA and ISO specs for SM Connector RL

**Singlemode Connection Return Loss Requirements**

| AS/NZS 3080<br>ISO/IEC 11801<br>EN 50173-1 | TIA 568.C-3 |
|---|---|
| **35 dB** | **26 dB** |

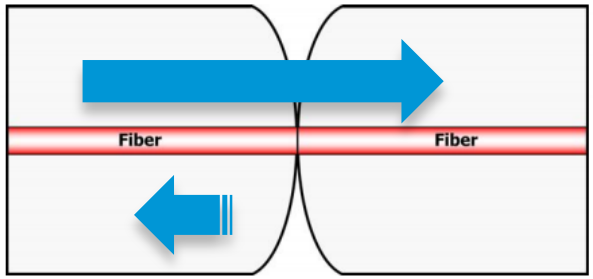
Harmonize TIA specs with 35 dB, a value used by the rest of the world since 2002, per international standard ISO/IEC 11801.

Multinational Corporations in USA also use the component specs of ISO/IEC 11801 in data centers.

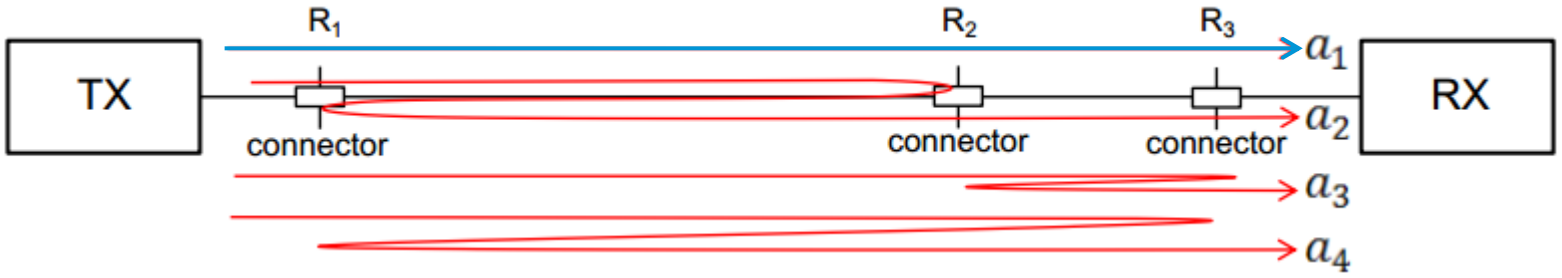
A single standard across the world will reduce cost for everyone.

# What is Connection Return Loss?

- Ideally, a mated connector pair should pass 100% light through. But contaminants and geometry imperfections cause some light to reflect in the opposite direction.
- Return Loss is a measure of this reflected amount of power. Also known as discrete reflectance.

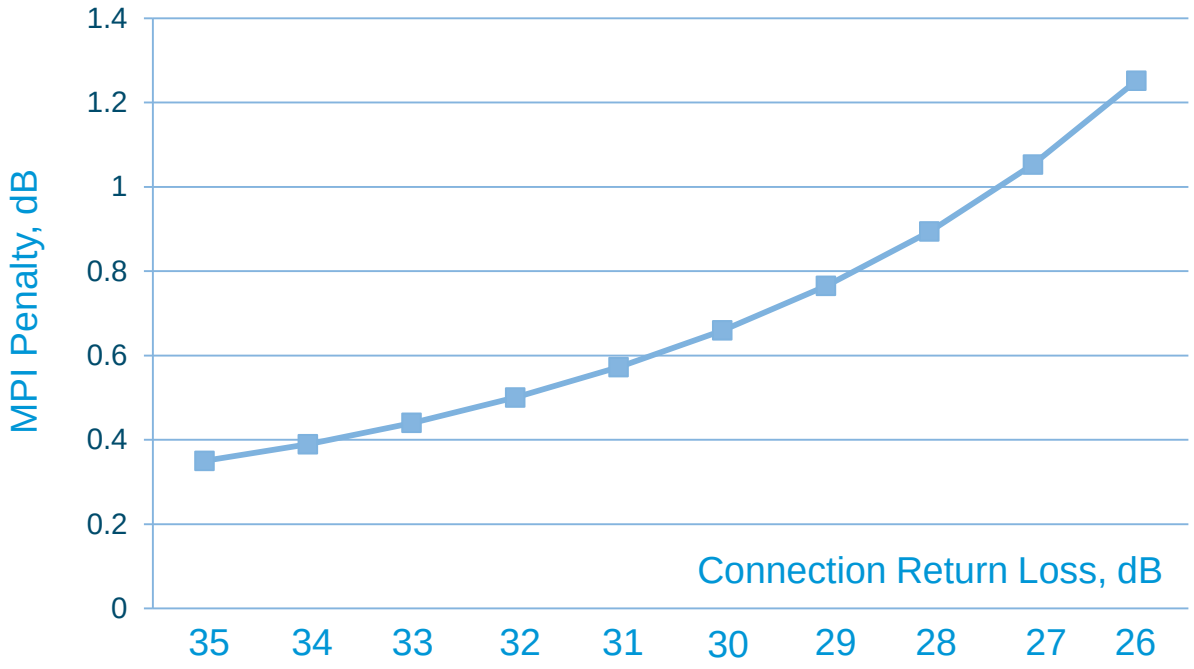



- If a link has multiple connections, this can create MPI (Multipath Interference) Noise, which degrades performance. The problem multiplies with number of connections.



# Important: MPI is a Universal Problem for 400G SMF Links

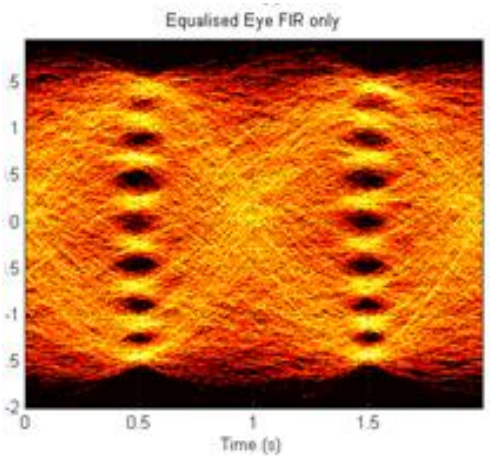
- If we look at some possible 400G SMF link scenarios:
  - 8 Lanes of 50G Binary, 4 Lanes of 100G PAM, 4 Lanes of 100G DMT
  - …where 4 or 8 Lanes are achieved with either Parallel Fiber or WDM…
- Due to very tight link budget, MPI will adversely affect ALL of the above variants, albeit in varying amounts.




Example:
Binary OOK,
4 connections
in link, Upper
Bound method.

# Why It Matters

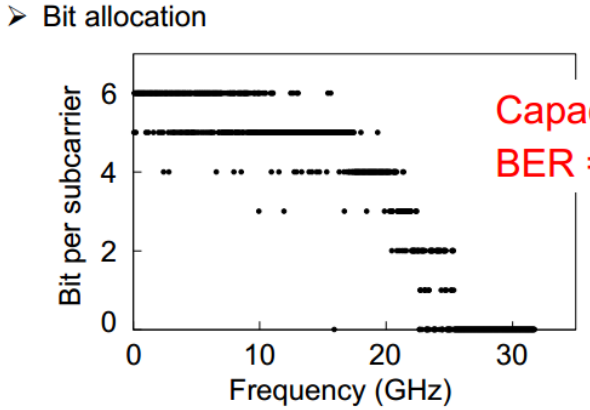
- High RL leads to MPI (Multipath Interference) Noise, which degrades SNR.
- In PAM links, it produces amplitude-proportional noise*.
- In DMT links, it degrades aggregate SNR across multiple subcarriers.
- This can be generalized to any Higher Order Modulation (HoM) or high baud rate scheme to be used for 400G.
- To overcome it, implementers have to use stronger FEC or lower-RIN lasers, etc. This can add complexity, latency, power dissipation or cost.




## PAM

Measured Optical PAM8 Eye, equalized after oscilloscope capture, at pre-FEC BER.

*For MPI Overview, see
http://www.ieee802.org/3/100GNGOPTX/public/may12/bhatt_01_0512_optx.pdf




## DMT

Capacity = 114Gbps

BER = $4.85 \times 10^{-4}$

For DMT Presentation, See
http://www.ieee802.org/3/bm/public/jan13/tanaka_01_0113_optx.pdf

# What is the commercial reality? Is 35 dB achievable?

- Yes. Nearly all major suppliers of factory-terminated pigtails and patch-cords routinely exceed 35 dB RL spec by a wide margin.
- This leaves plenty of margin for degradation over lifetime in the field.

CORNING | Cable Systems

UPC Return Loss, typical: > **58 dB**

COMMSCOPE®

TeraSPEED Pre-Radiused
Return Loss, min: **55 dB**

TE connectivity

UPC Return Loss, min: **55 dB**

PANDUIT™

UPC Return Loss, min : 55 dB
(>58dB typ.)

# What about “backwards compatibility” with 26 dB?

- There will be some (unknown) portion of infrastructure that will not be compliant to the new spec by the time 400G standard is ratified. And also remember that implementers are free to design to 26 dB if they so choose.
- What can we in the IEEE standards body do about it?

  If we agree that it will be a small and rapidly shrinking minority, we can simply choose not to be backwards compatible. Any 400G SMF link will need to be compliant to the new standard. (The “look forward” approach.)

  If we think the added complexity is justified, we can specify a stronger FEC as an optional fallback solution. In the presence of 26 dB RL connections, that link will use the stronger FEC.
- What should we do about it?

  It will be up to this group to decide. Whatever path we choose, we should not delay the decision of harmonizing the TIA spec with what an international standard and supplier ecosystem are already following.

# Why Now?

- Because 802.3 infrastructure should keep up with architecture. And 400G is such a moment.
- And because the timing is right for TIA as well.

  The TIA is undertaking a revision of 568-C.3 to create 568-3-D. The official ballot will open this summer (summer 2013).

  There will be a minimum of two ballot cycles for technical comment resolution.

  The earliest it could be approved is at the February 2014 meeting of TR-42.

  We should not miss this window.

# What's the Next Step?

- Subject to 802.3 WG's approval, we recommend that a liaison communication be sent to TIA TR42.11, requesting their consideration for this harmonization. Suggested core text:
- "The 400 Gb/s Ethernet Study Group recommends that to accommodate the cabling infrastructure performance requirements that may be required by the increasing data rates of future Ethernet variants, the TR42.11 subcommittee should consider changing the Return Loss specification for single-mode connections to 35 dB, harmonizing with ISO/IEC 11801, as part of the revision to TIA-568-D. The Return Loss value of 35 dB represents a balanced choice when taking into account factors like performance improvement, harmonization of global specifications, and state of the art of technology today."