40GBASE-T Channel Models
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Chris DiMinico
MC Communications/Panduit
cdiminico@ieee.org

Supporters

- **Ron Nordin, Bob Wagner - Panduit**

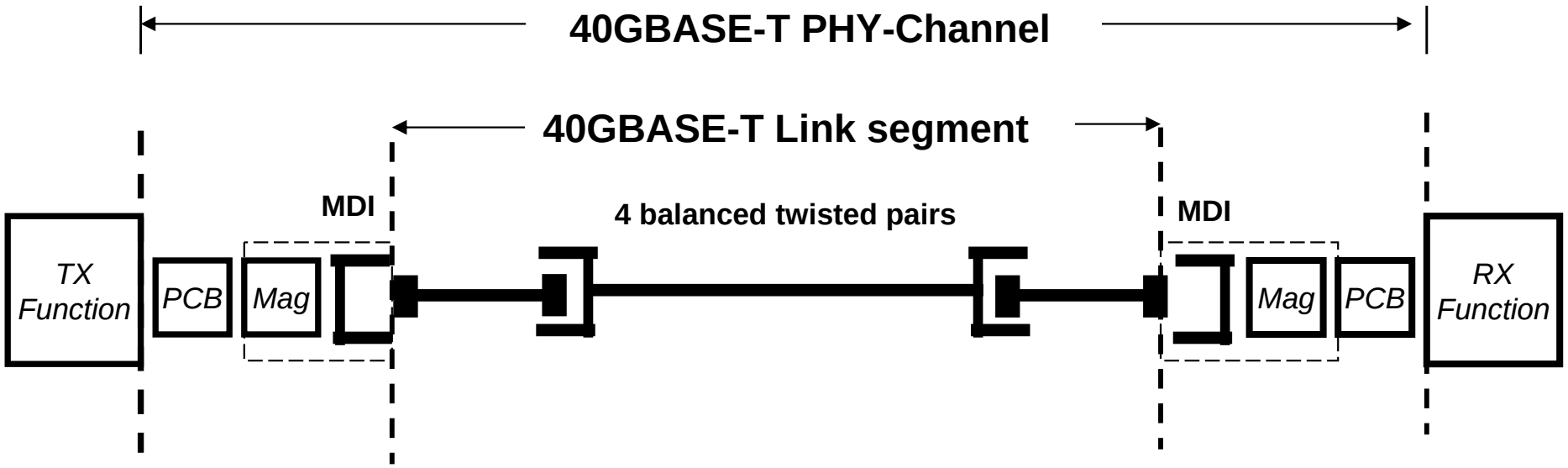
Purpose

- Required SNR and margin

- Considerations for the insertion loss and noise budgets based on PHY-channel component measurements received and cabling specifications.

  - Tx/Rx (Host) PCB loss
  - Magnetics/MDI
  - Link segment

40GBASE-T PHY- Channel



Modeling to optimize PHY and PHY-channel performance

PHY-Channel

- MDI/Magnetics
- Host PCB
- Link segment - based upon copper media specified by ISO/IEC JTC1/SC25/WG3 and TIA TR42.7
  - –4 pair, balanced twisted-pair copper cabling
  - –Up to 2 connectors
  - –Up to at least 30 meters

Required SNR

Gap to Capacity and Link Margin

- The gap to capacity of a PAMn constellation is almost independent of the constellation size.
- Using a proper coded modulation scheme, the gap to capacity is predominately a function of the binary performance of the code.
- In this analysis we assume a fixed gap to capacity independent of the symbol rate and dictated by the choice of the FEC.
- In additional to the gap to capacity, we assume a certain operational margin for reliable performance.

Table: Margin Assumptions

Gap to Capacity (dB)	4
Operating Margin(dB)	3

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Source: dabiri_01a_0113_NGBT

Operating SNR and Symbol Rate

Source: dabiri_01a_0113_NGBT

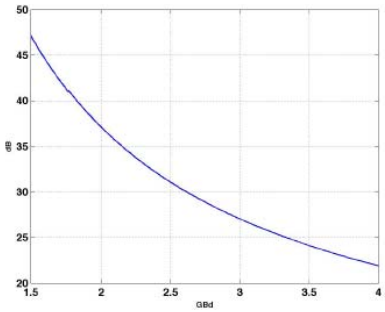

Figure: The Required SNR vs Symbol Rate for the 40m Cable

Combining the gap to capacity and the link margin in one variable, g, the required SNR is computed as:

$$\mathrm{SNR}(f_s) = g\,(2^{\frac{2R}{f_s}} - 1) \gtrapprox g\,2^{\frac{2R}{f_s}}$$

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SNR Margin to Capacity Definition

- Let *BW* be the design bandwidth in Hz.
- Let *C'* be the desired capacity per twisted pair in b/s (=10Gb/s)
- From Shannon-Hartley the theoretical min SNR in dB is given by

$$SNR_C = 10log_{10}(2^{(C'/BW)} - 1)$$

- For each cable parameter, define the SNR margin to capacity, ***SNR_margin*$_{cable\_param}$*(BW)***, as the required constant change in loss across all frequencies in order to reach SNR_C.

Source: grimwood_01a_0113_NGBT.pdf

IEEE 802.3 NGBASE-T Study Group Jan 2013

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Importance of Insertion Loss

- All PHY assumptions assume cancellation of internal noise
- All PHY assumptions are driven by external or circuit noise limitations
- Insertion loss determines TX power, RX noise floor, Cancellation and Equalization requirements
- Existing PHYs can be examined for IL
  - IL at the middle of the used band (1/2 Nyquist) is a good single metric, sometimes Nyquist is used too.

IL sensitivity is common to all estimations

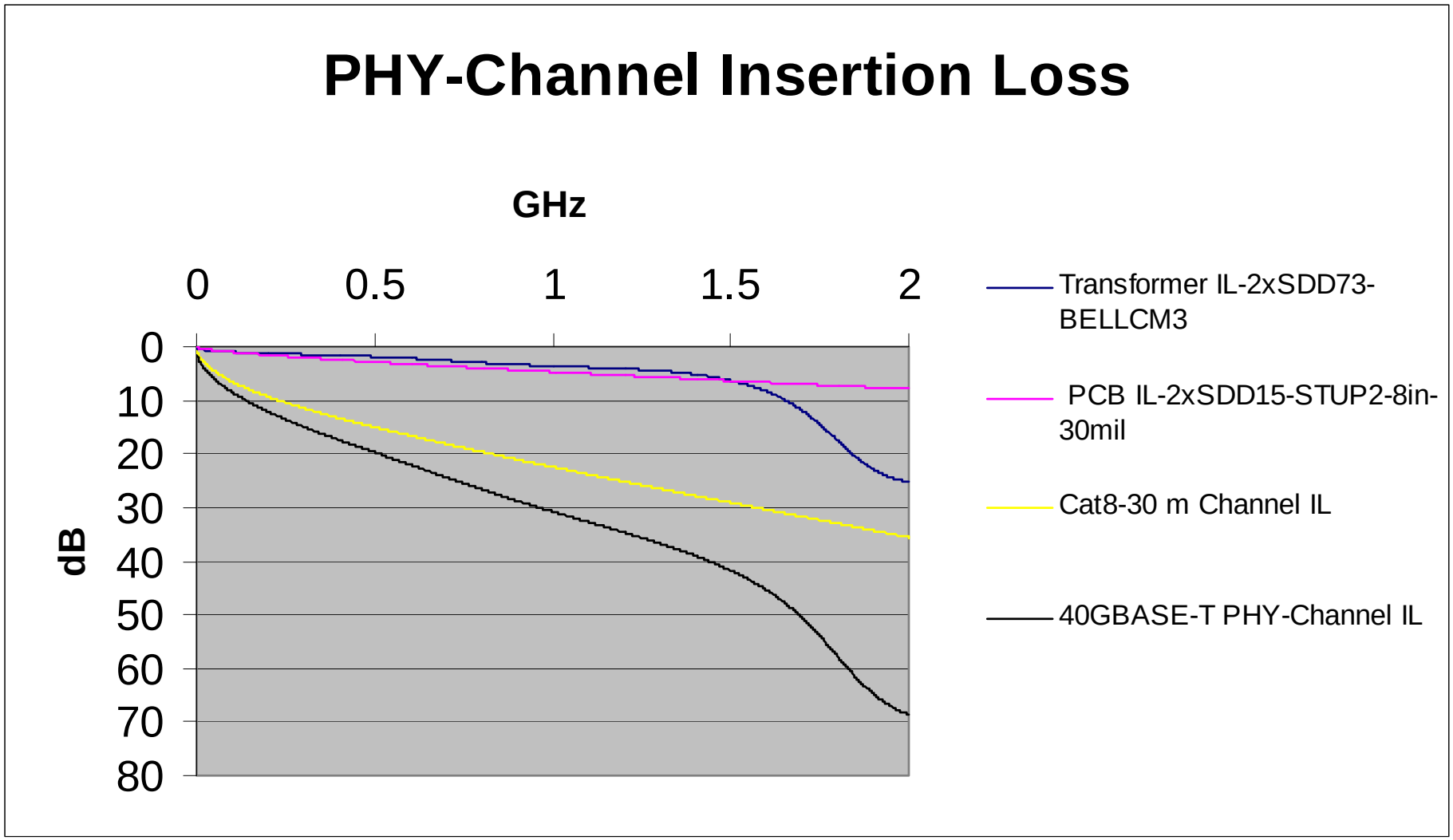
Source: zimmerman_01a_0113_NGBT.pdf

Required SNR

- Required Saltz SNR
  - 10 Gb/s Shannon capacity
  - Gap to capacity = 4 dB , Operating Margin = 3 dB

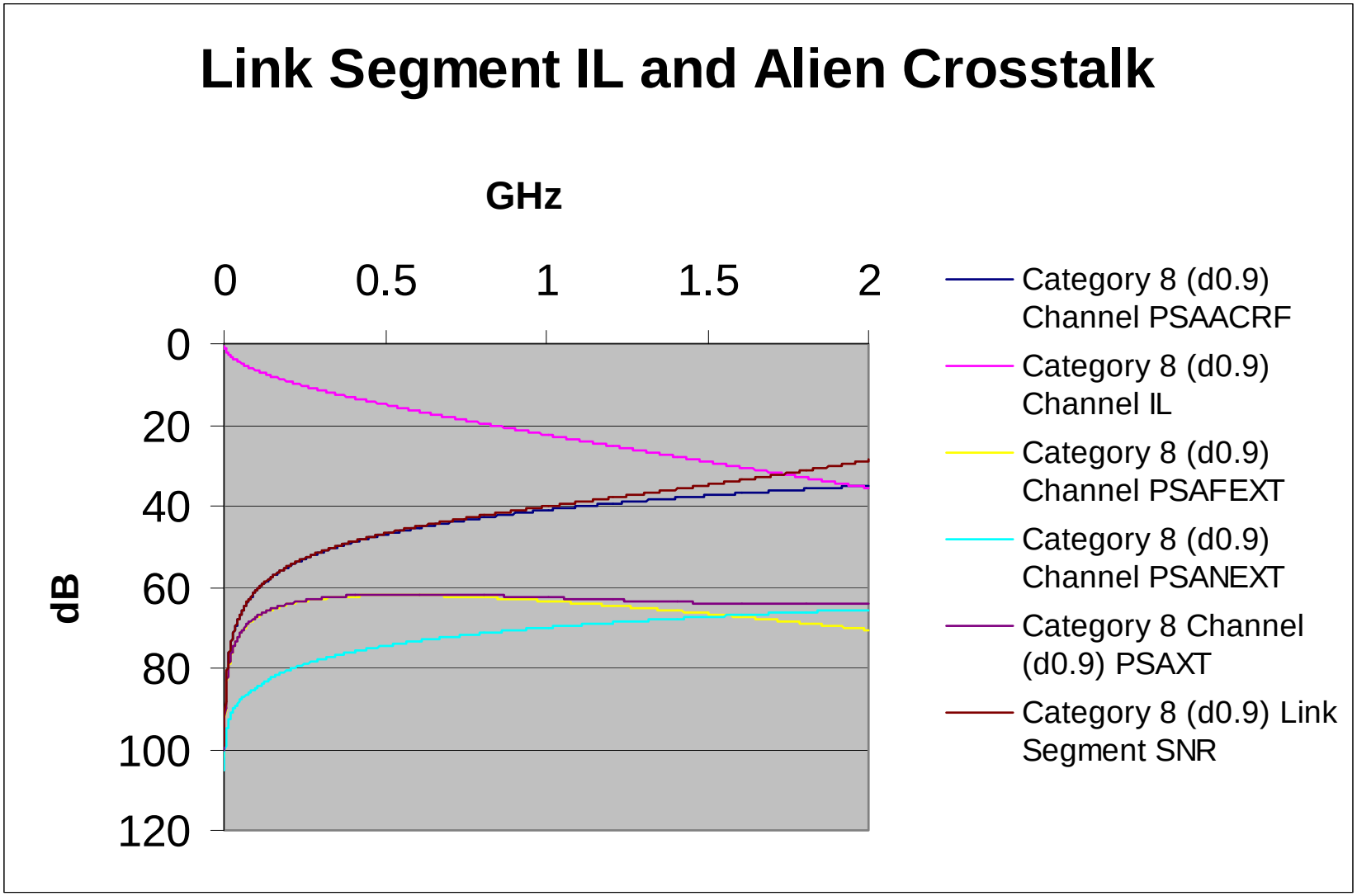
GbD	Required SNR	GHz	Required SNR
1.5	47.14	0.75	47.14
2	37.10	1	37.10
2.5	31.08	1.25	31.08
3	27.07	1.5	27.07
3.5	24.20	1.75	24.20
4	22.05	2	22.05

PHY-Channel Insertion Loss



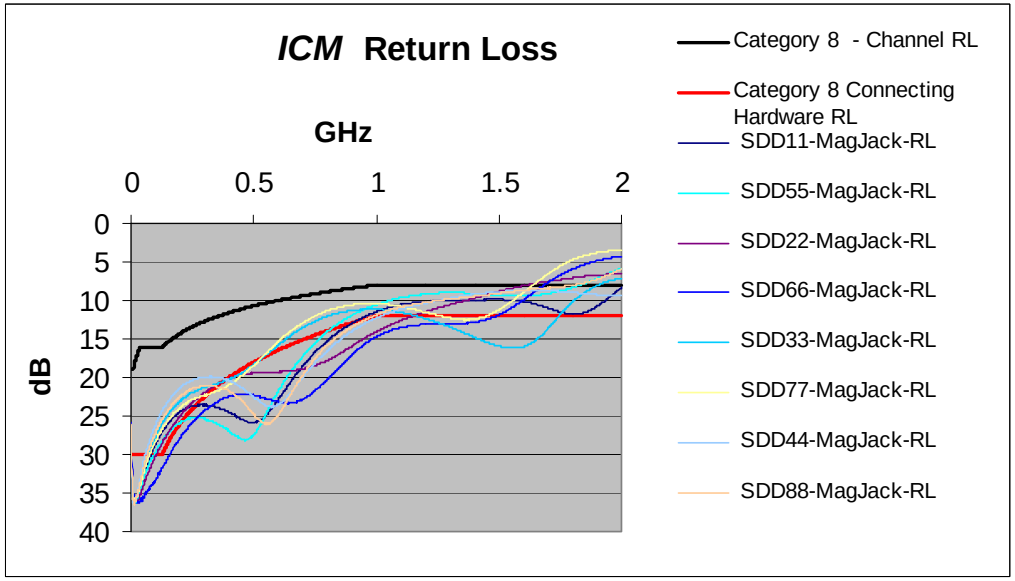
- IL PCB model 8in-30 mil and IL transformer track to 1.5 GHz

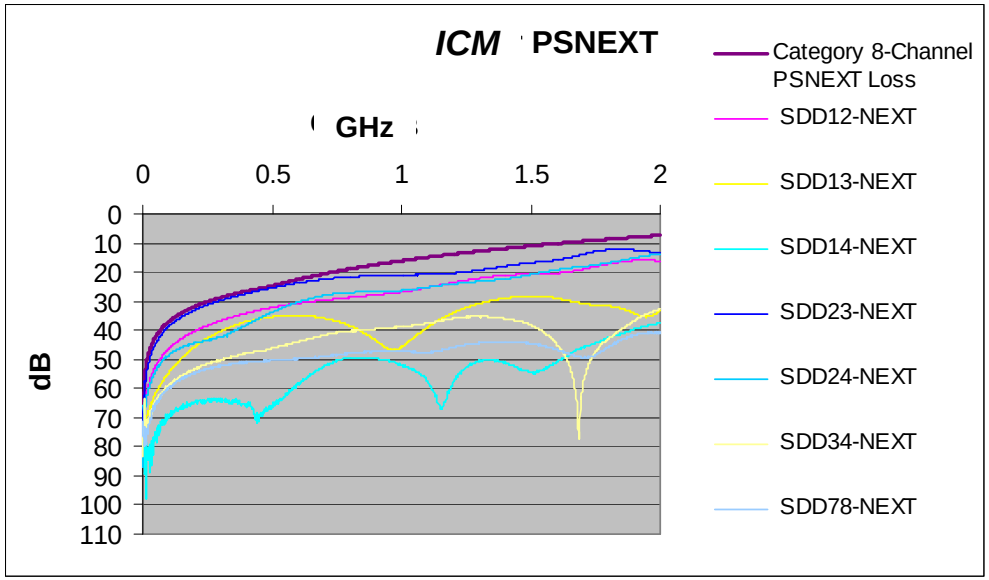
Link Segment Insertion Loss and AXT



SALZ SNR = 27.9 dB, integration BW=2 GHz:

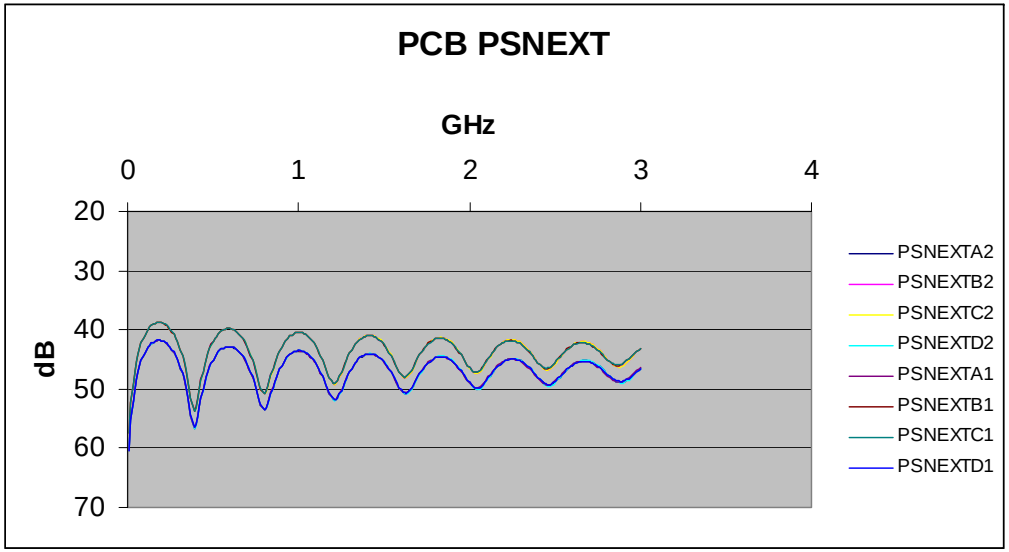
ICM Characteristics

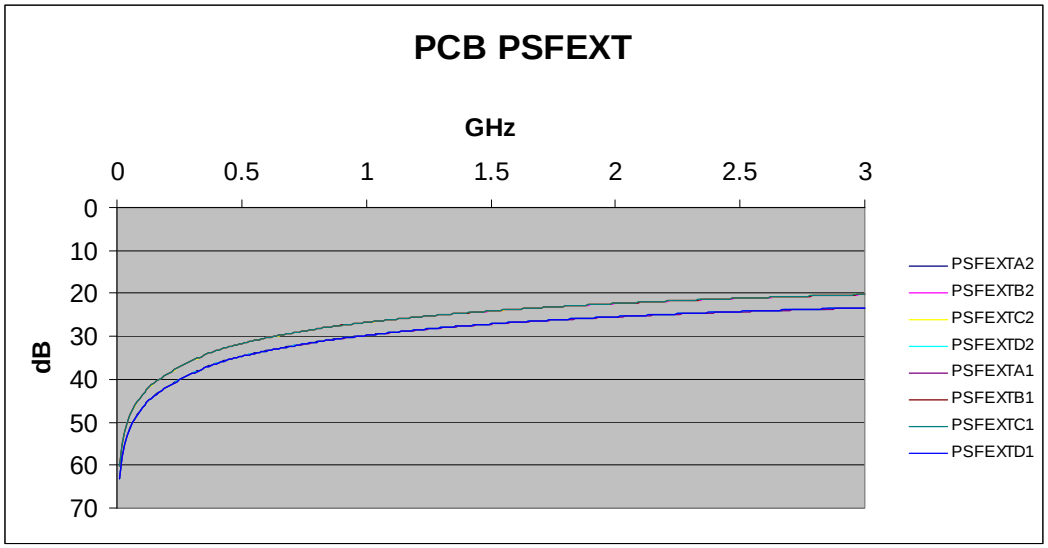


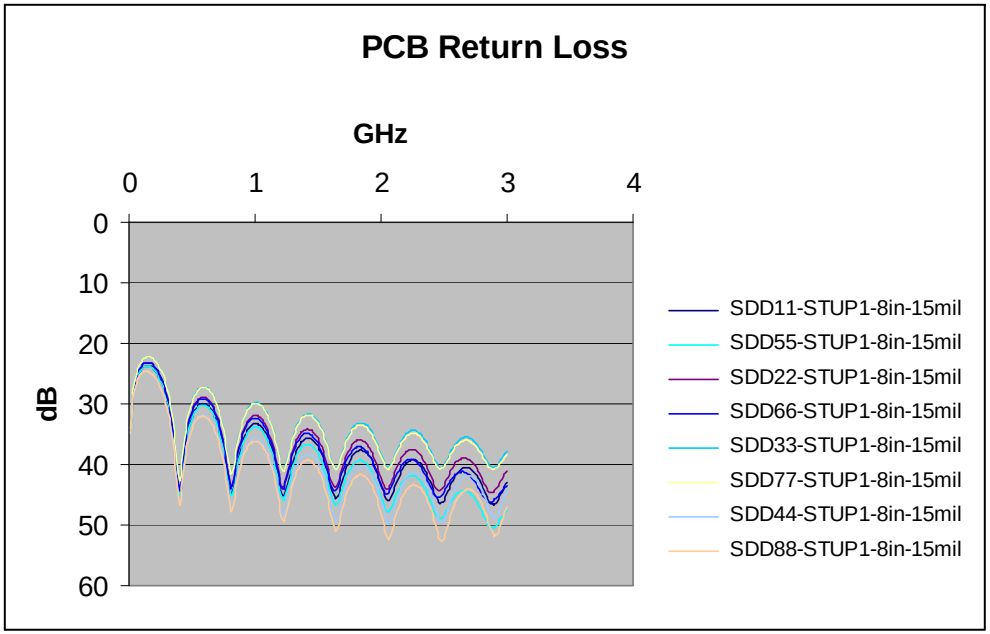


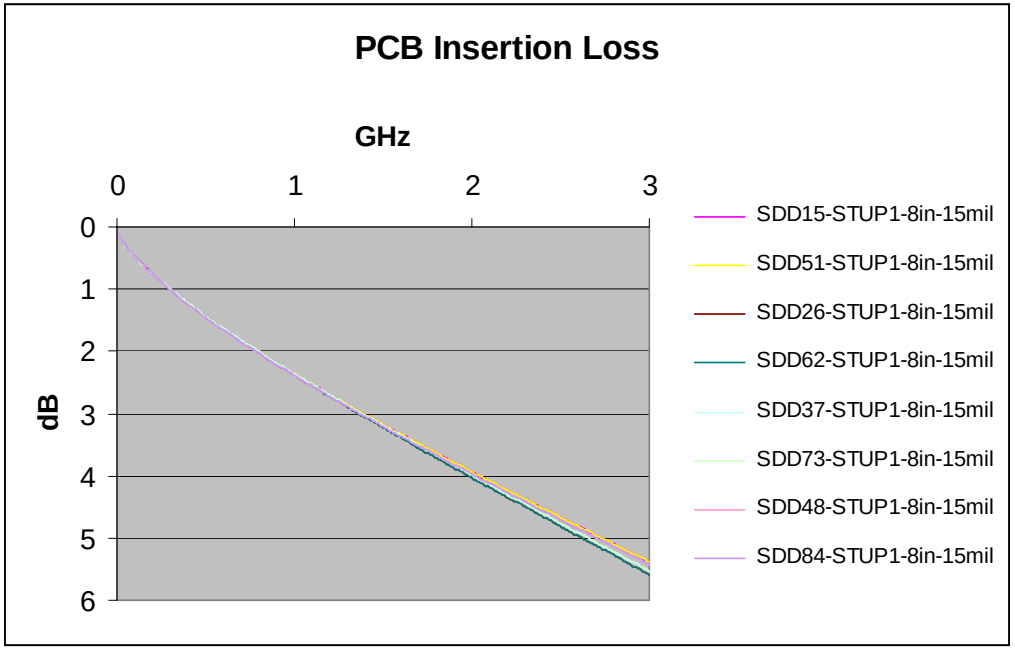
- ICM return loss and PSNEXT compared to Link Segment Limits
- Transformer models dominate PHY-Channel performance
- Scaling Link Segment measurements will result in small changes in performance results relative to ICM

PCB Characteristics – 8in – 15mil isolation

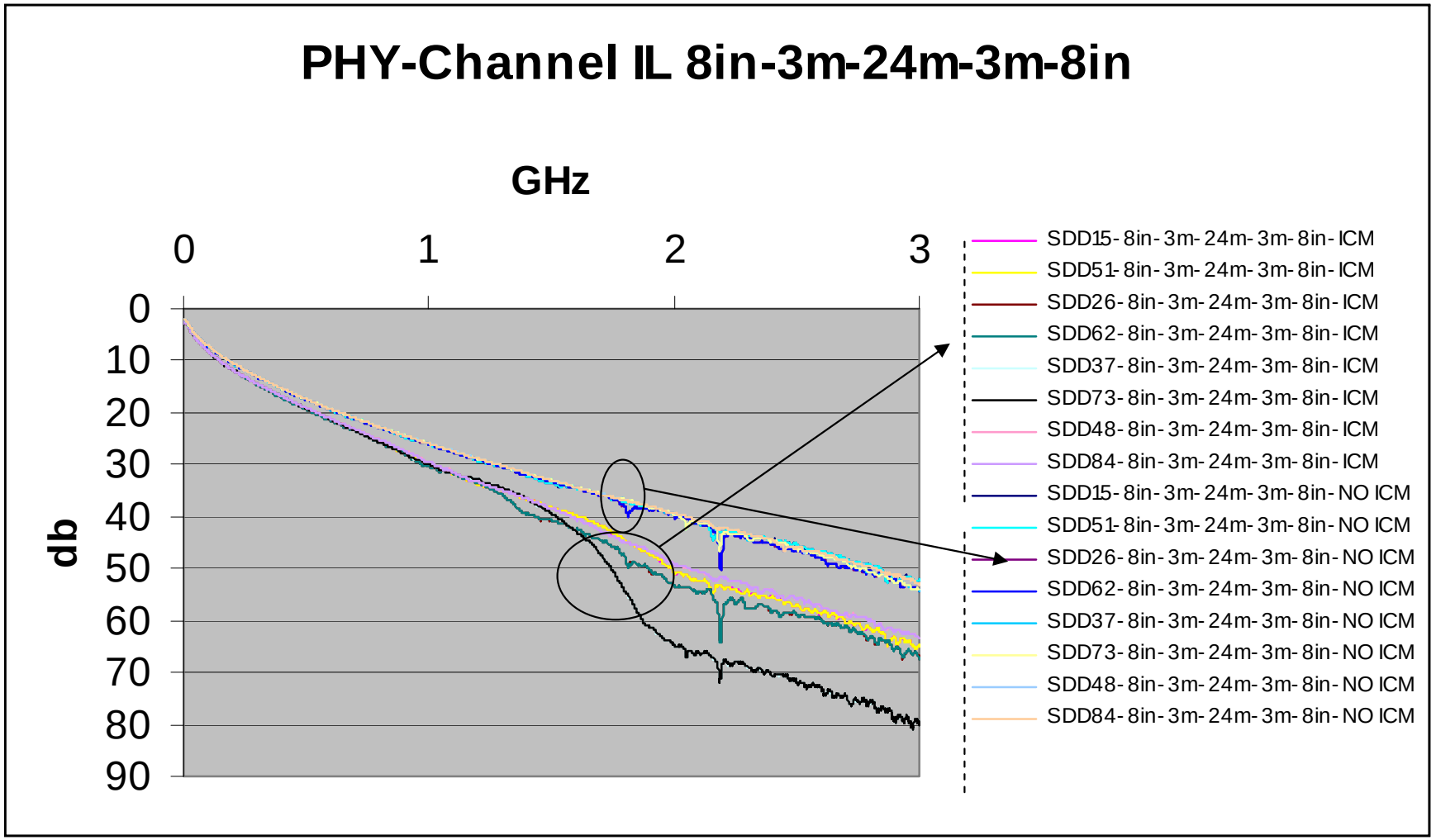






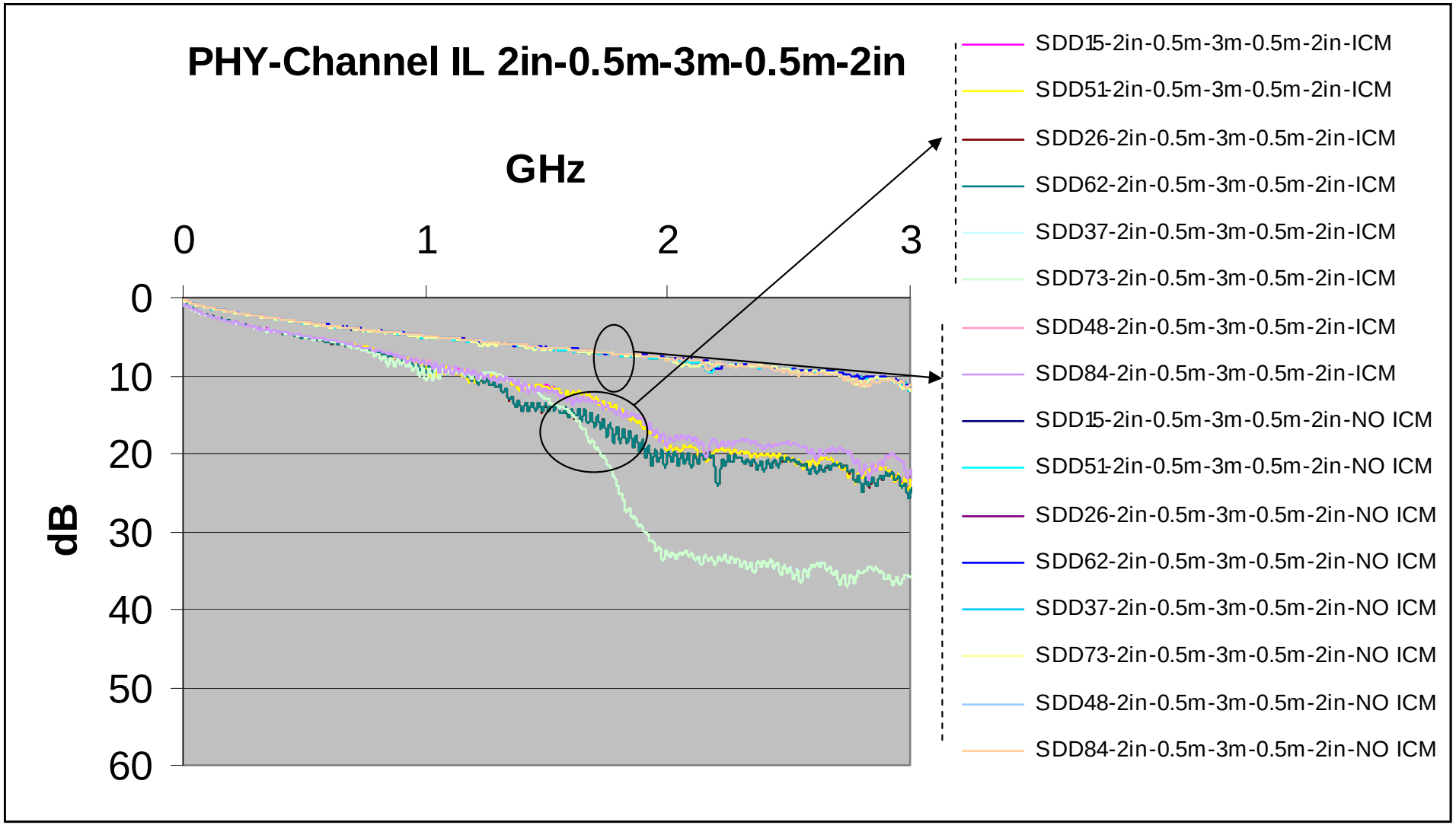


PHY-Channel Insertion Loss – Impact of ICM



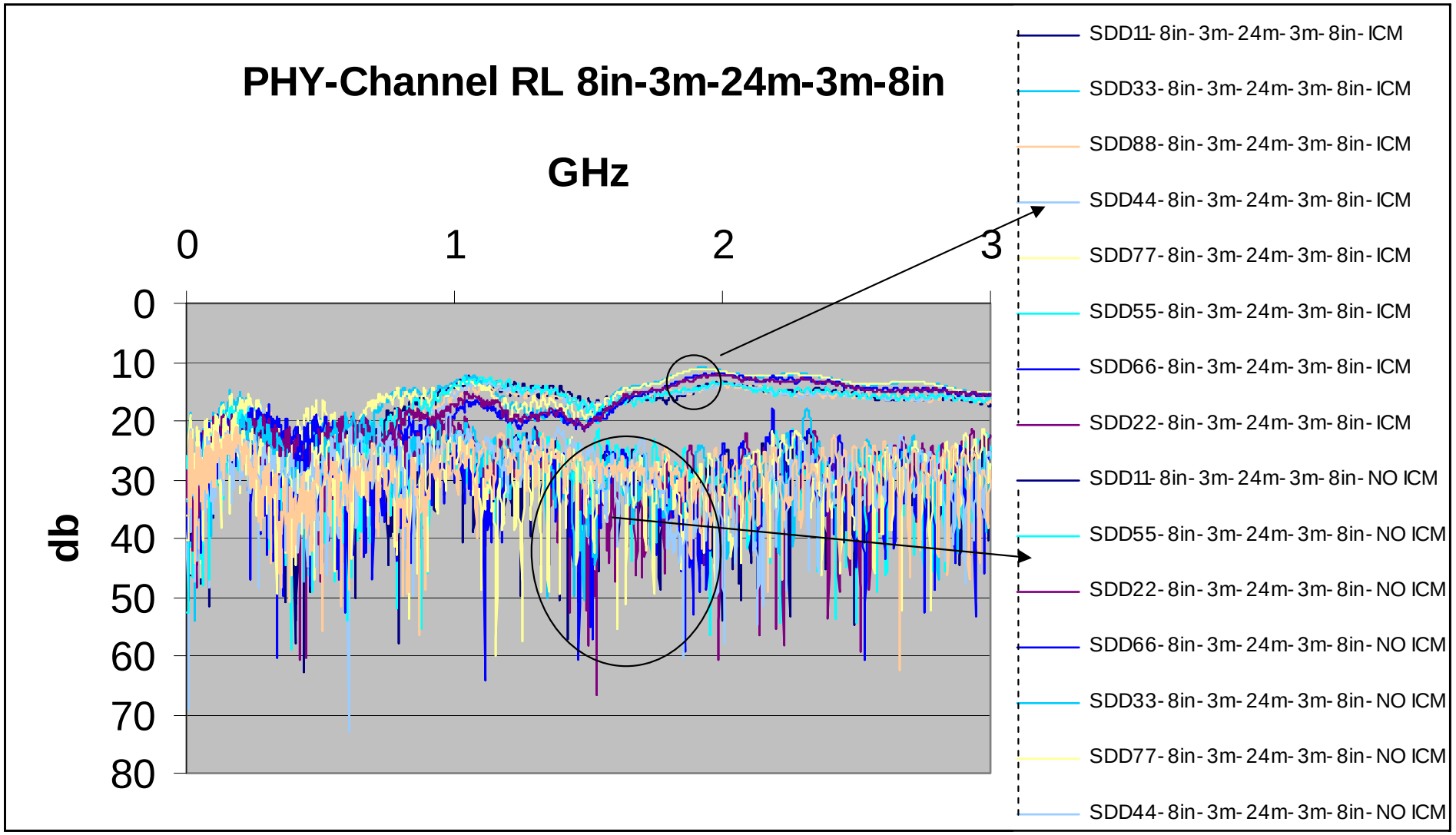
PHY-Channel – concatenated s-parameters

PHY-Channel Insertion Loss – Impact of ICM



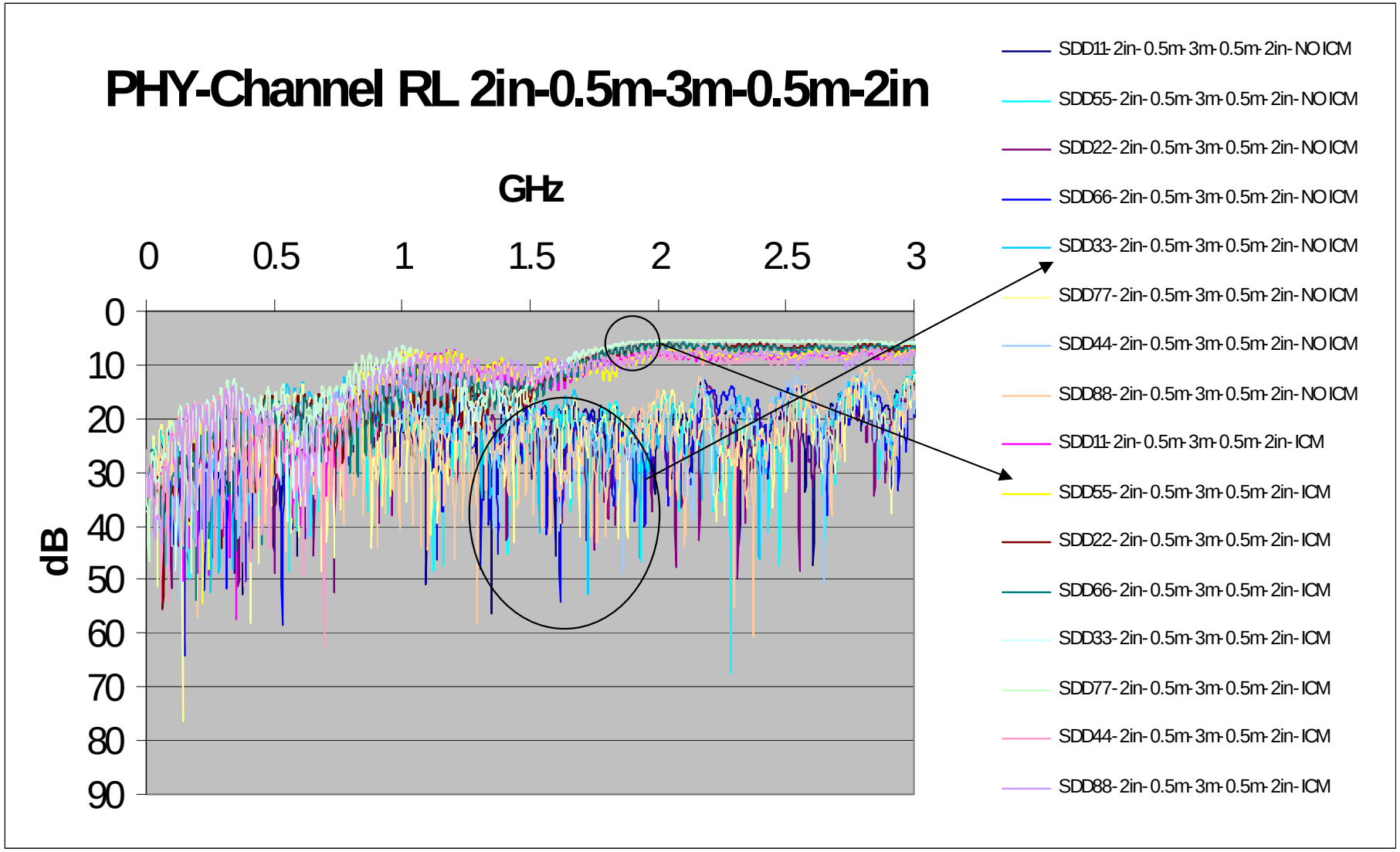
PHY-Channel – concatenated s-parameters

PHY-Channel Return Loss – Impact of ICM



PHY-Channel – concatenated s-parameters

PHY-Channel Return Loss – Impact of ICM



PHY-Channel – concatenated s-parameters

Summary

- Required SNR and margin reviewed

- PHY-channel concatenated from component measurements/modeled presented.
  - Tx/Rx (Host) PCB loss
  - Magnetics/MDI
  - Link segment

- ICM contribution to PHY-channel IL and RL considered.

- Concatenating scaled cabling (link segment) measurement data may exhibit only small changes in PHY-channel transmission characteristics and performance relative to ICM.