# 10GBASE-KR for 40G Backplane

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# Outline

**This contribution discusses,**

- **Performance based on 10GBASE-KR Std**
- **Theoretical Limit (Saltz SNR) and Time Domain Simulation**
- **Performance Improvement**
- **Summary**

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# 40G Backplane

## A Single Lane, 10GBASE-KR 802.3ap, Clause 72

***Main Requirements***

**Signaling: 10.3125Gbaud(+/-100ppm), 2PAM**

**Transmitter: 1200mVpp Max, 3-tap Pre-Equalization, Total Jitter < 28%UIpp**

**Return Loss: 9dB  50M ~ 2.5GHz, 12dB/dec. from 2.5 ~ 7.5GHz**

**Insertion Loss: < ILmax(f), 24.5dB at 5GHz,  Informative**

**Cross-talk: Defined as ICR, Ratio of IL to Power sum crosstalk, PSXT**

**ICR ≥ ICRmin = 23.3-18.7Log(f/5G), Informative**

**BER: Better than 10**(-12)**

***Receiver Interference Tolerance***

**Broadband noise: 5.2mVrsm(5GHzband)**

**Jitter UI p-p: 13% (random), 3.5%(DCD), 11.5%(sinusoidal)**

**Total 17 channels are uploaded to verify the system performance.**

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# Channel discussed by 10GBASE-KR

## TYCO, 7 Channels

| Description | | Channel Name | Line Card | No. Connectors | Backplane | Total Length | Loss @ 5GHz |
|---|---|---|---|---|---|---|---|
| TYCO 7 cases [1] | Signal path One FEXT Two NEXT | Case1 | 10” Nelco4000 13SI | 2 | 20” Nelco4000 13SI | 40” | 22.9dB |
| | | Case2 | 10” Nelco4000 13 | 2 | 20” Nelco4000 13SI | 40” | 24.1 |
| | | Case3 | 10” Nelco4000 6 | 2 | 20” Nelco4000 13SI | 40” | 26.6 |
| | | Case4 | 6” Nelco4000 13 | 2 | 20” Nelco4000 13SI | 32” | 19.0 |
| | | Case5 | 6” Nelco4000 13 | 2 | 10” Nelco4000 13 | 22” | 14.2 |
| | | Case6 | 6” Nelco4000 13SI | 2 | 10” Nelco4000 13 | 22” | 16.4 |
| | | Case7 | 6” Nelco4000 13SI | 2 | 1” Nelco4000 13SI | 13” | 12.9 |

[1] http://www.ieee802.org/3/ap/public/sep04/dambrosia_01_0904.pdf

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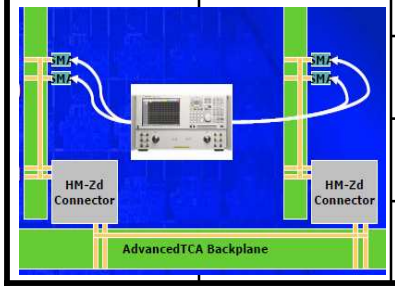
# Channel discussed by 10GBASE-KR

# Molex, 2 channels and Intel, 8 channels

| Description | | Channel Name | Line Card | No. Connectors | Backplane | Total Length | Loss @ 5GHz |
|---|---|---|---|---|---|---|---|
| Molex<br>2 cases [2] | Signal oath<br>3 FEXT<br>4 NEXT | 1m_Improved_1 | 2.5” +2.5”<br>Nelco4000<br>13SI | 2 | 35”<br>Nelco4000<br>13SI | 40” | 22.6 |
| | | 1m_Improved_2 | 2.5” + 10.5”<br>(?) | 2 | 25”<br>Nelco4000<br>13SI | 38” | 17.8 |
| Intel<br>8 cases [3] | Signal path<br>2 FEXT<br>6NEXT | T1 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 16.8 |
| | | T12 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 24.4 |
| | | T20 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 27.4 |
| | | B1 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 8.9 |
| | | B12 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 14.1 |
| | | B20 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 17.4 |
| | | M1 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 12.3 |
| | | M20 | 5” + 5”<br>Nelco4000-6 | 2 | --- | --- | 19.8 |




[2] http://www.ieee802.org/3/ap/public/mar06/oganessyan_01_0306.pdf

[3] http://www.ieee802.org/3/ap/public/jun05/peters_01_0605.pdf

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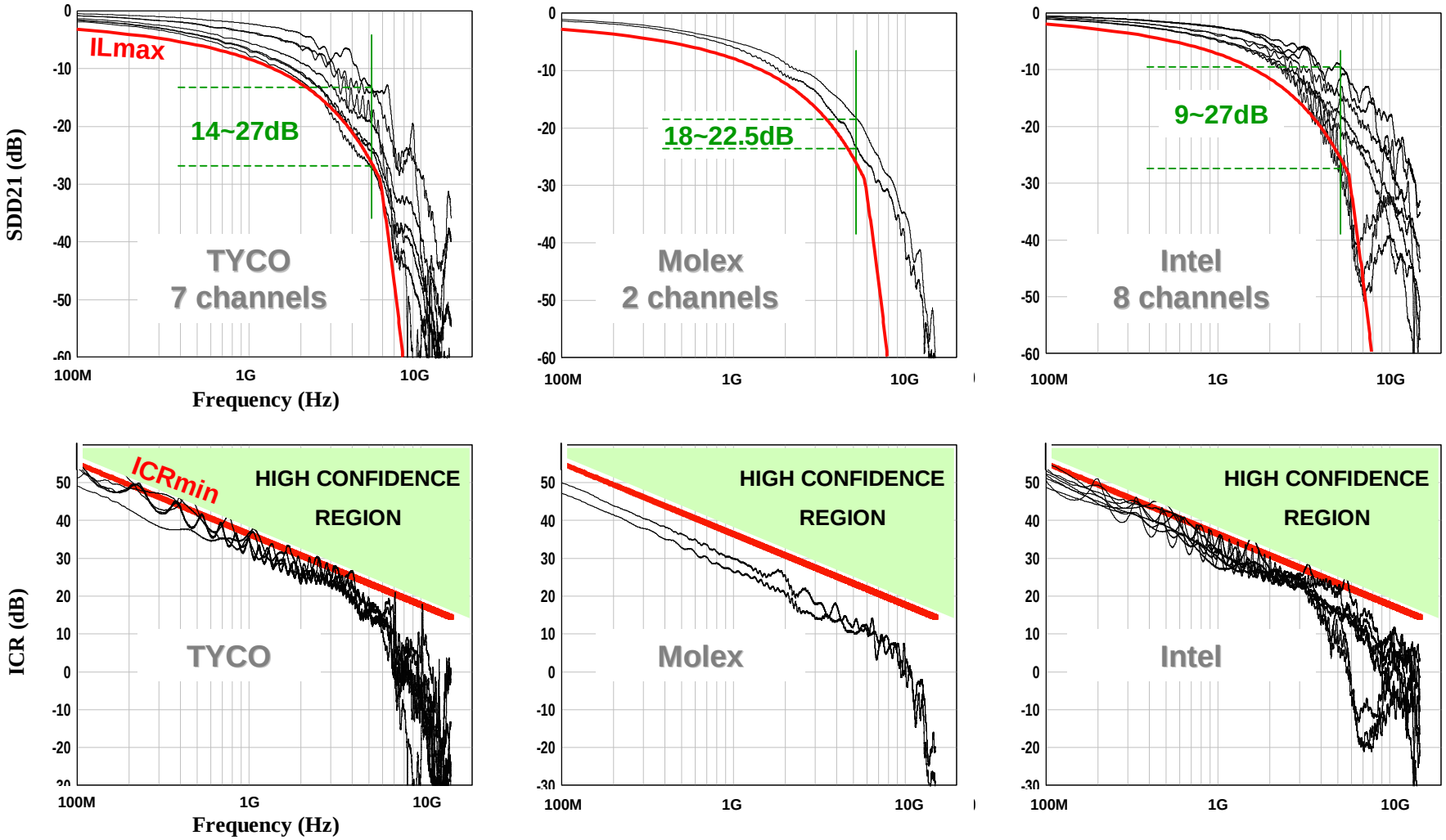
# IL and ICR




**No cases are in “HIGH CONFIDENCE”**

# Performance Study

**The purpose is to confirm 10GBASE-KR applicability for 40G.**

**1st Step: Calculate theoretical SNR (Saltz) against broadband noise, measured crosstalk, and IC electronic noise.**

**2nd Step: Check Jitter and other IC implementation loss by the time domain simulator**

**3rd Step: Performance Improvement by Crosstalk Canceller**

**"Noise Margin" is used throughout the discussion.**

**Noise Margin = [Achievable SNR] – $SNR_{required}$**

**$SNR_{required}$ is 17dB for 2PAM, BER = 10 **-12**

**It is preferred to be greater than on the order of 6dB for a robust operation.**

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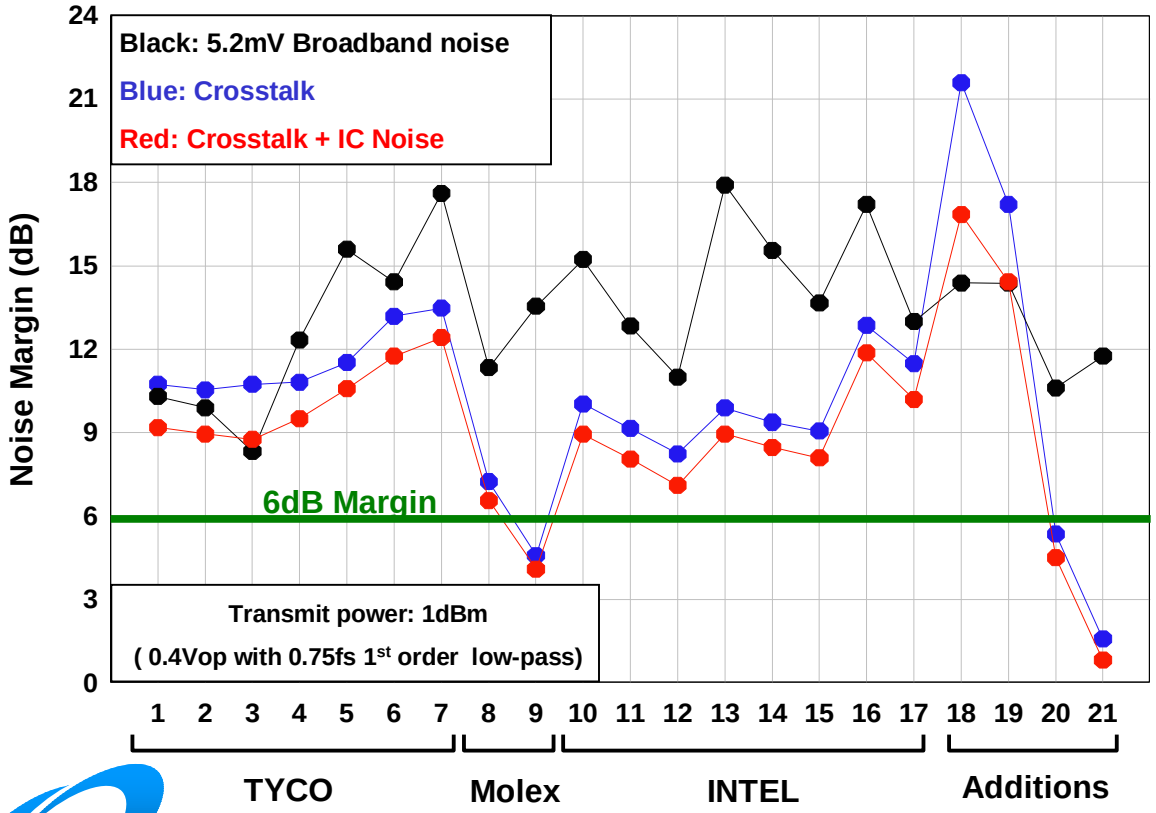
# Noise Margin by Saltz

**Three scenarios :**

1. **5.2mV-rms broadband noise defined by 10GBase-KR Receiver Interference Tolerance**
2. **Measured crosstalk from S-parameter**
3. **Crosstalk + -140dBm/Hz (IC electronic noise 32nV/sqrt(Hz) into 100ohm)**




**Backplane Channel Provided to the 802.3ap**

**All except few cases met 6dB margin.**

**Feasible subject to IC noise floor.**

**The result does not include**

**- Jitter**

**- Implementation loss**

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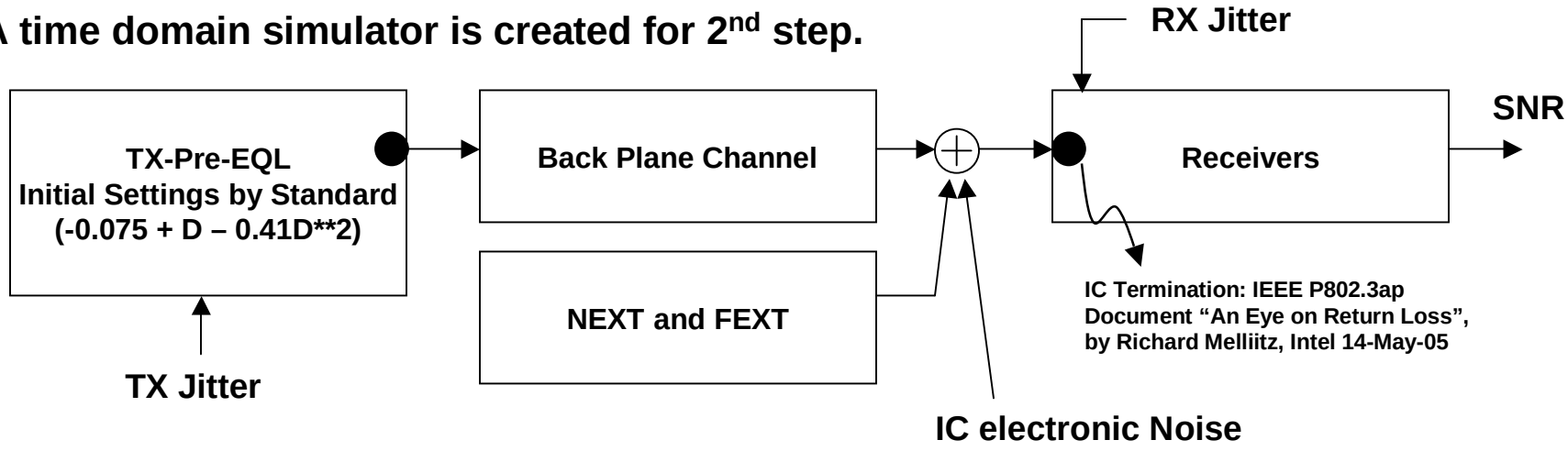
# Jitter and Implementation Loss

**A time domain simulator is created for 2nd step.**




| | |
|---|---|
| **TX Jitter** | **0.28UIpp (5 sigma) jitter** |
| **RX Jitter** | **0.21 UIrms random jitter (VCO) + systematic timing recovery jitter (bigger than receiver interference tolerance)** |
| **IC Electronic Noise** | **-140dBm/Hz** |
| **FFE** | **8tap** |
| **DFE** | **16, 32, 64, and 128tap** |

**Crosstalk Canceller added later as an option**

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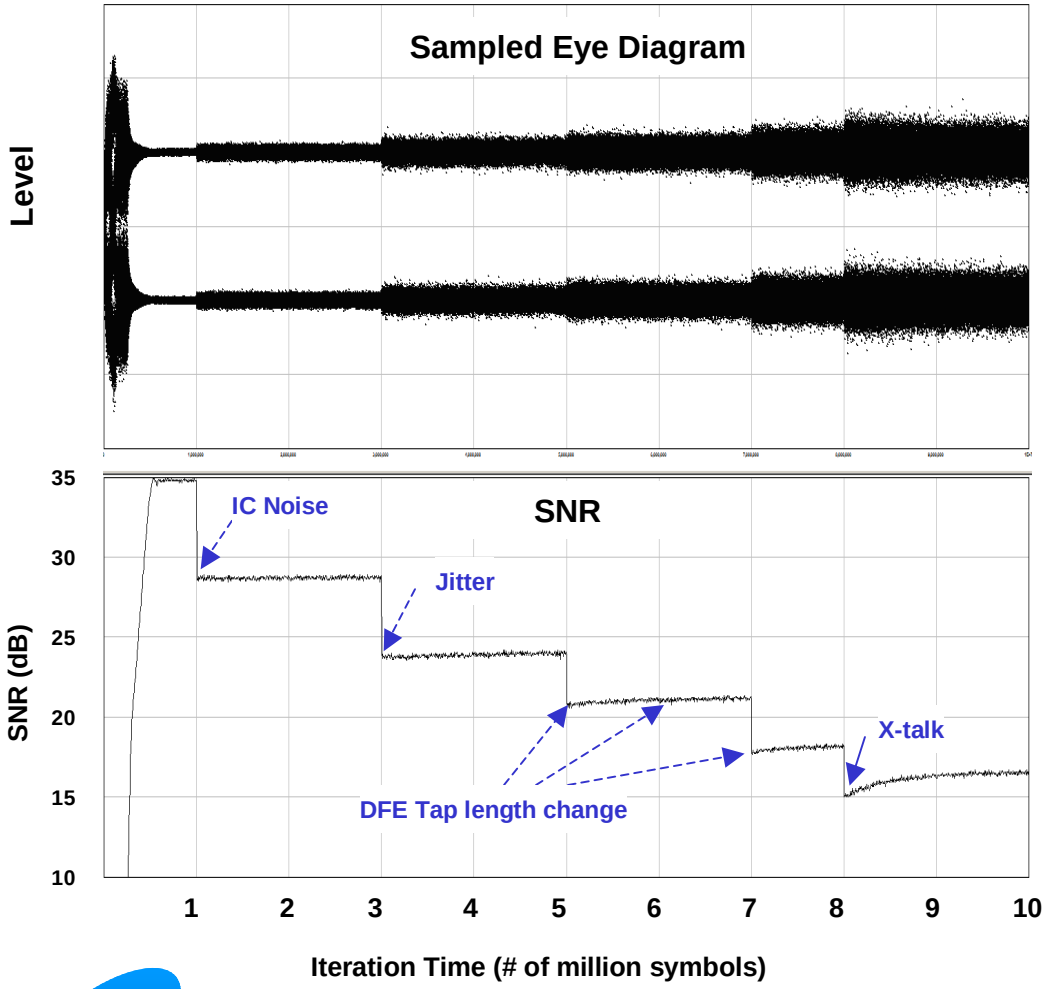
# Jitter and Implementation Loss




**Following impairments are added one by one after the receiver is fully activated after 1 million-symbol iterations.**

**- IC noise, -140dBm/Hz**
**- TX and RX Jitter**
**- DFE tap length reduction, 128, 64, 32, 16**
**- FEXT + NEXT**

**CH12(Intel T20) is shown as an example. All channels were simulated to verify the degradation.**

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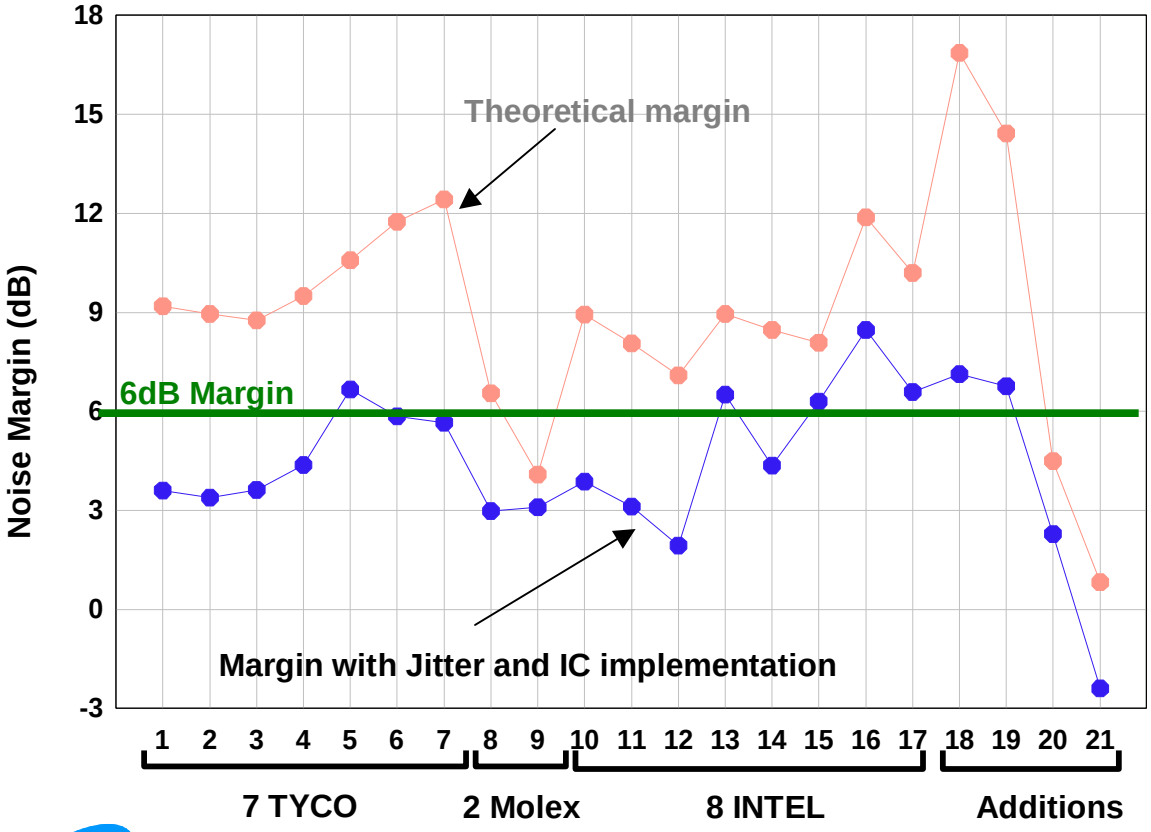
# Margin with Jitter and IC

**Jitter and IC implementation loss + Crosstalk + -140dBm/Hz IC noise**

**Receiver Resource: 8 tap FFE + 128 tap DFE**




**Result represents high performance design and could degrade more.**

**Marginal for many cases.**

**Industrial systems need to be robust against alien noise, impulsive noise, etc.**

**How can they be improved?**

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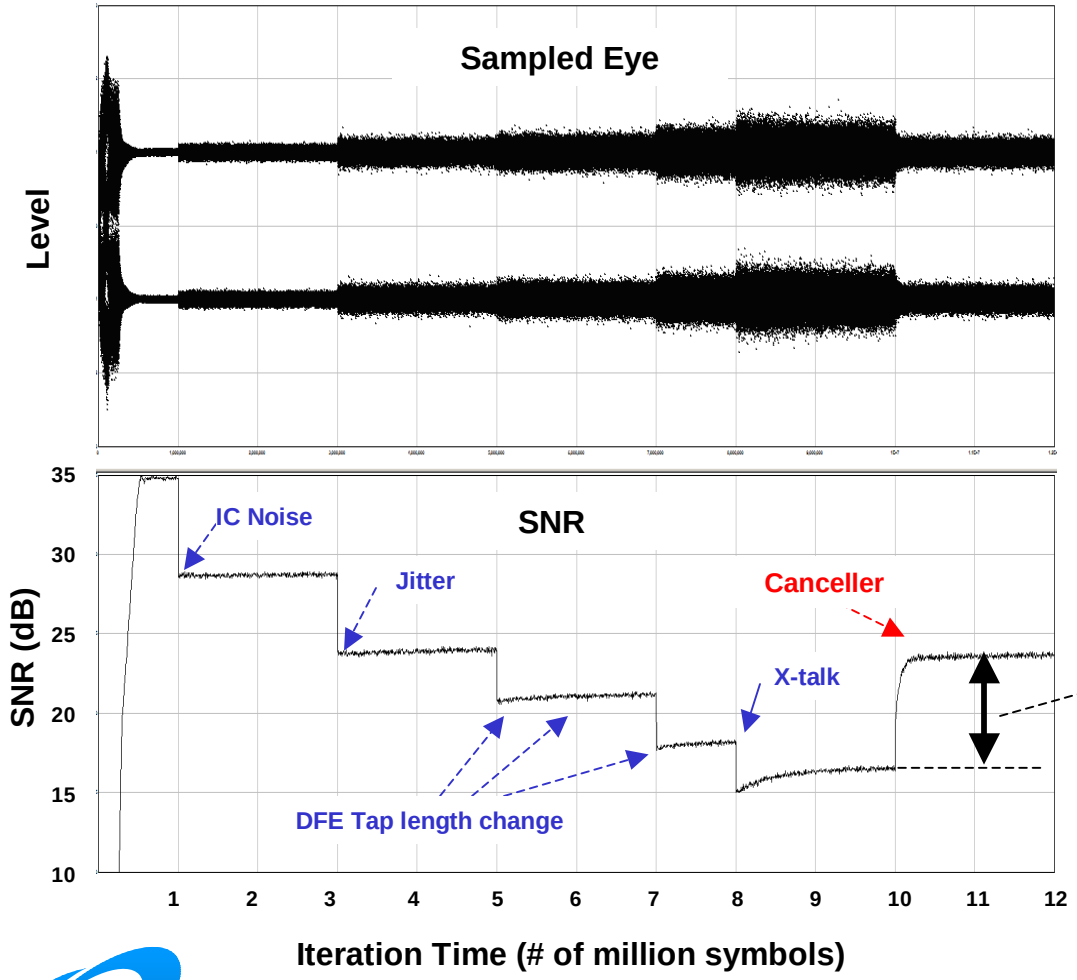
# Crosstalk Canceller




**Crosstalk cancellation mode (2 million iterations) is added at the end of the behavioral simulation.**

**Margin was improved by 7dB in this example (CH12, Intel case-3).**

**Similar improvements shown in the previous chart were confirmed for all cases.**

**7dB improvement**

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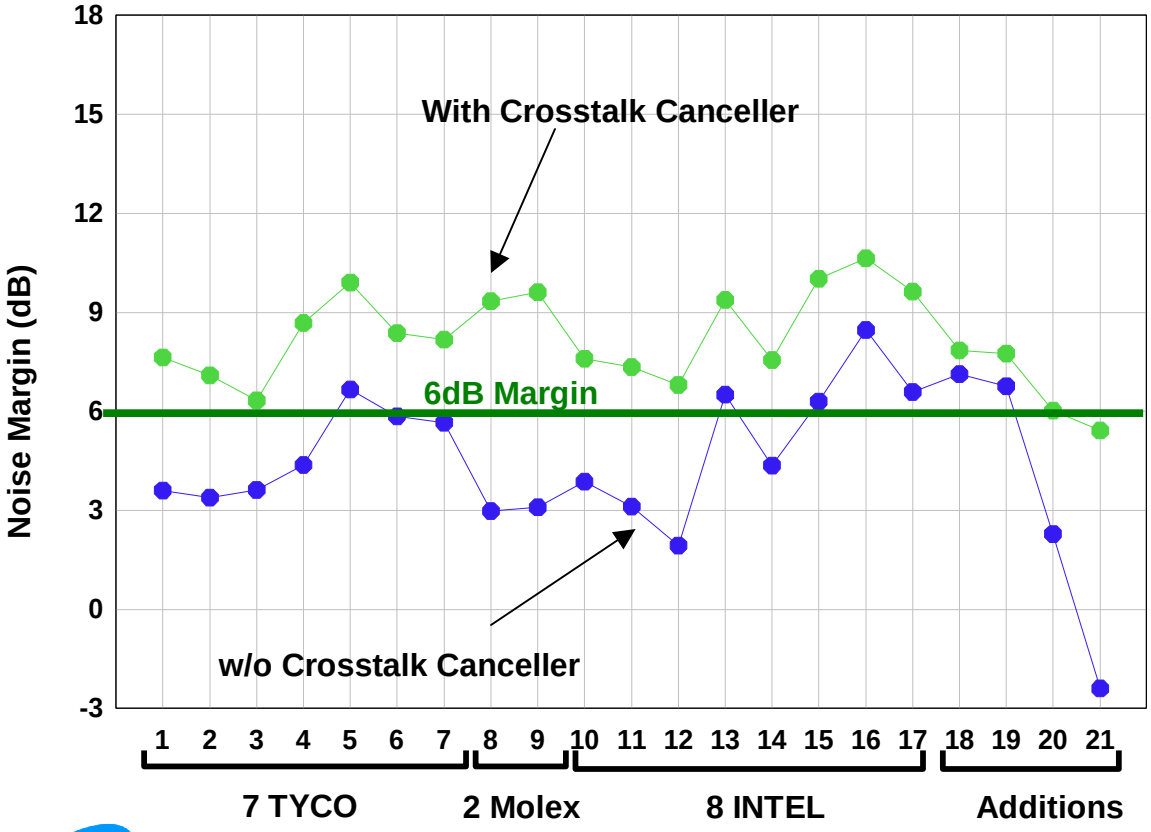
# Crosstalk Canceller

**Crosstalk cancellation is possible with 4-lane structure of 40G backplane.**




**More than 6dB improvement can be made with crosstalk canceller.**

**Another ~2dB improvement can be with optional FEC.**

**6dB margin is feasible.**

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# Summary

**Performance of 10GBASE-KR is estimated with key IC implementation impairments.**

**- Performance is marginal with the industrial grade backplane channels.**

**- Solution as crosstalk canceller.**

**- Even better margin can be obtained by with optional FEC.**

**- Recommend HSSG to define additional channel bundling parameters to address crosstalk.**

**Therefore, 10GBASE-KR is a good fit as a baseline for 40G system.**

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