Proposal for Optical Link Model

Naoto Saeki
NEC Corporation

Supporters

Name	Company
Hiroshi Hamano	Fujitsu
Tetsuya Yokomoto	Fujitsu Access
Motoyuki Takizawa	Fujitsu Access
Hiroki Ikeda	Hitachi
Keiji Tanaka	KDDI R&D Labs.
Junichi Nakagawa	Mitsubishi
Naoki Suzuki	Mitsubishi
Naoto Saeki	NEC
Akio Tajima	NEC
Hiroki Yanagisawa	NEC
Ken-ichi Suzuki	NTT-AS
Takashi Nakanishi	NTT-AS
Shinji Tsuji	Sumitomo

***Alphabetical order in company name**

Issues in the current spreadsheet

Dispersion Penalty

✓ One of the most important issue is that chromatic dispersion penalty of single mode LD due to “chirp” is not accurately incorporated in the spreadsheet.

http://www.ieee802.org/3/efm/public/sep01/dawe_1_0901.pdf

✓ On page 12 in the above document, there is a sentence saying 'Not at all accurate for chromatic dispersion penalty of single mode lasers (“chirp”)'.

Dispersion Penalty

✓ In specifying the power budgets, it is very important to know how much dispersion penalty should be allocated in channel insertion loss.

✓ However, with the current spreadsheet, we may not be able to estimate the dispersion penalty properly.

✓ Considering this situation, we should discuss how we incorporate the dispersion penalty in the spreadsheet.

✓ It will need consistency with Power Budget Ad-hoc in which dispersion penalty of 1dB is adopted as a default number.

Proposal for Dispersion Penalty estimation

✓In 10GEPON, we will use SLM-LD and will not use MLM-LD. In this case, dispersion penalty will be dominated by LD “chirp”, not by mode-partition-noise.

✓ So we would like to propose to use Agrawal’s formula as one of candidate to estimate the chromatic dispersion penalty caused by LD “chirp”.

$$\delta_d = 5Log_{10}\left[\left(1+8C\beta_2 B^2 L\right)^2 + \left(8\beta_2 B^2 L\right)^2\right] \qquad \beta_2 = -\frac{\lambda^2}{2\pi c} D$$

C: Chirp Parameter
L: Transmission distance
B: Bit rate

Source: Govind P. Agrawal, Fiber-Optic Communication Systems, Third edition

Difficulties in Dispersion penalty estimation

✓ However, Chirp parameter ‘C’ in the equation (or can be expressed by α parameter) is very difficult to predict.

- It depends on extinction ratio for direct modulation model.
- Chirp is not a static, but is a dynamic value.

✓ Calculated penalty has strong dependence on ‘C’ as shown in the graph on next page.

✓ We will need to find an appropriate ‘C’ value for accurate penalty estimation based on the experimental results.

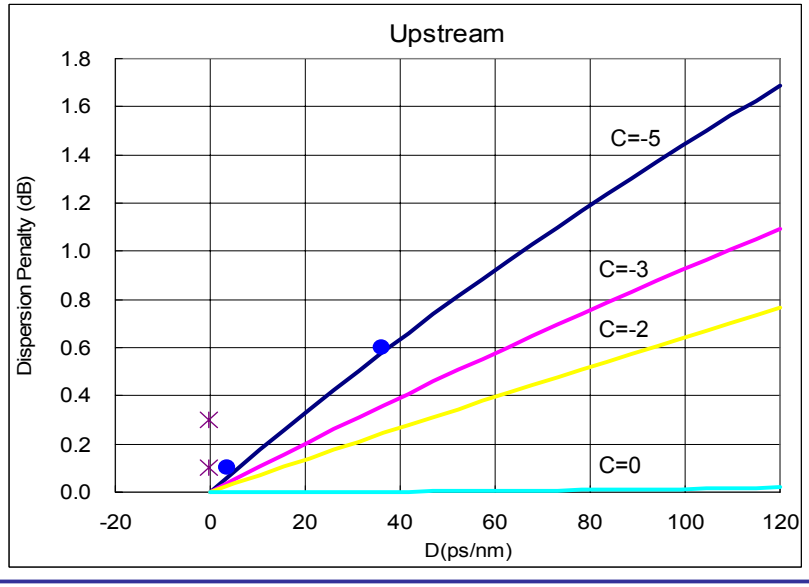
Theory vs. Experimental results (tentative)

✓ Three vendors have thankfully provided the experimental data so far.

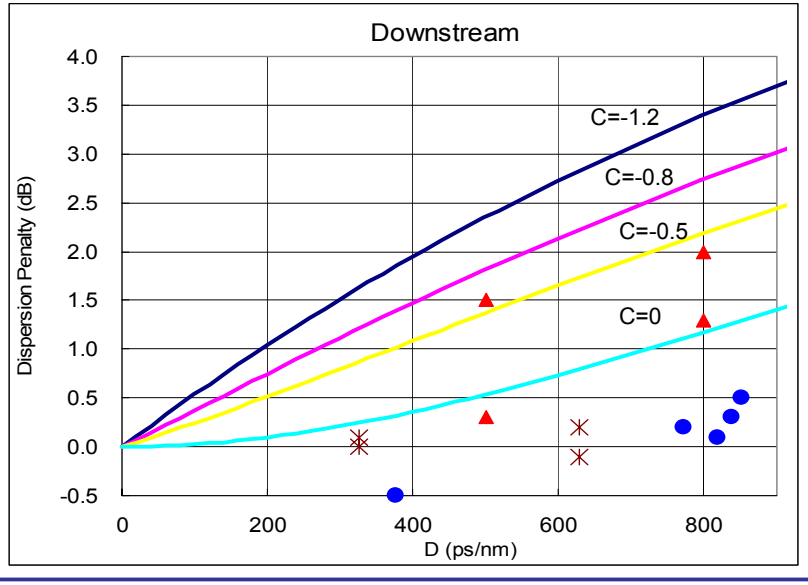
✓ However, too few data to compare with the theory.

✓ More experimental results are necessary for verification of the proposed formula.

13xx nm DM-DFB for Upstream@10G



15xx nm EML for Downstream@10G



Another issues

TDP (Transmitter and Dispersion Penalty)

✓ TDP is used in the power budget table in 802.3ah/802.3ae and is a dominant factor of allocation for penalties.

✓ However, TDP is based on the actual measurement and there is no documentation for theoretical formula.

✓ Is it reasonable or possible to consider large TDP values such as 3~4 dB (which is shown in the current spreadsheet) into the power budget table ?

Another issues

ISI (Inter Symbol Interference)

✓ ISI penalty is one of the dominant factor of channel link loss.

✓ ISI penalty in the spreadsheet includes dispersion penalty, but it is not based on chirped SLM-LD.

✓ How does ISI penalty interact with TDP ?

✓ Is it reasonable to apply the current link model to 10GEPON as it is ?

Summary

- New formula for estimating dispersion penalty for 'chirped' LD is proposed.
- Verification of the proposed formula based on experimental results is now under way.
- We need discussion how we handle TDP and ISI in the current spreadsheet.