Considerations on X00 Gb/s 40-80km interfaces with appropriate support for DWDM systems

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Introduction

- During the b10k meeting in Charlotte, September 2017, in http://www.ieee802.org/3/B10K/public/17_09/villarruel_b10k_01b_0917.pdf it was proposed to introduce objectives for:
  - 200 Gb/s 40-80km interface with appropriate support for DWDM systems
  - 100 Gb/s 40-80km interface with appropriate support for DWDM systems
- What is the meaning of “40-80km interface with appropriate support for DWDM systems”?
- What is the impact?
- This presentation attempts to address these 2 questions.

Options to PHYs following the proposal

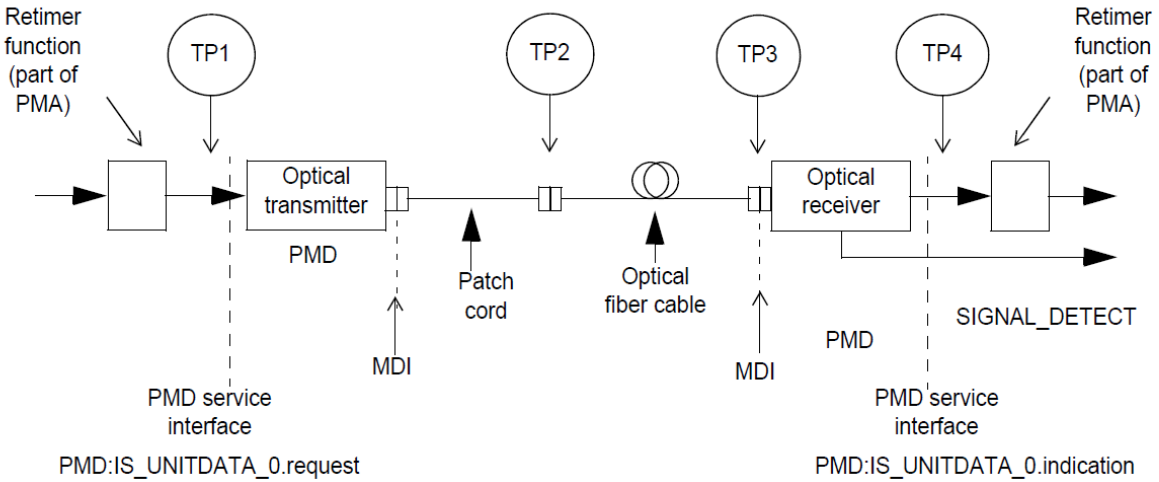
Two options are currently foreseen to accommodate "X00 Gb/s 40-80km interfaces with appropriate support for DWDM systems":

Option 1: A PHY that is based upon the conventional IEEE 802.3 passive optical link model, designed to operate in a passive link, with key characteristics (like adequate power levels and operation in 1550 nm window) allowing common devices for 802.3 and DWDM applications.

Option 2: A PHY that has detailed characteristics enabling direct operation of transceivers onto single-channel (wavelength) ports of a DWDM link (optical mux, optical amplifier, fiber, optical demux).

Option 1: Traditional Ethernet link model

In current IEEE 802.3 PHY's the optical link between transmitter and receiver, i.e. between TP2 and TP3, is in the form of a **passive** connection.



From P802.3cd D2.2

Figure 139–2—Block diagram for 50GBASE-FR and 50GBASE-LR transmit/receive paths

The fiber optic cabling (channel) characteristics are defined in terms of distance, loss, dispersion, DGD and return loss.

The transmitter / receiver specs are optimized for such a passive link.

Option 1 Spec

- A specification according to option 1 would contain conventional elements:
  - A table with transmit characteristics.
  - Another table with receive characteristics
  - A set of tables with characteristics of the (passive) fiber optic cabling (channel)
- This specification would be optimized for performance over a passive link of e.g. 40km.
- It could be set up such that it would not preclude reuse on DWDM networks elements, thus:
  - Operation 1550nm window instead of 1310nm window.
  - Appropriate optical power levels

Option 2: DWDM link interoperability

- In this case DWDM network elements are present between the transmitter and the receiver.
- These consist of a concatenation of optical multiplexer, optical amplifier(s), transmission fiber and optical demultiplexer.
- This concept of interoperability based on single channel inputs and outputs of DWDM network elements was introduced in ITU-T G.698.2 in 2007.
- These optical interfaces are commonly referred to as “coloured optics”, black link optics or IPoDWDM optics and sometimes even “alien” wavelengths.
- In contrast to specifications optimized for a passive link (optimized for mostly loss) a DWDM transmitter/receiver is optimized for maximum OSNR performance instead of maximum loss (due to presence of optical amplifiers inside the DWDM link).

How to specify DWDM interoperability?

- See: https://www.itu.int/rec/T-REC-G.698.2-200911-I
- Reference diagram for so-called “black link”

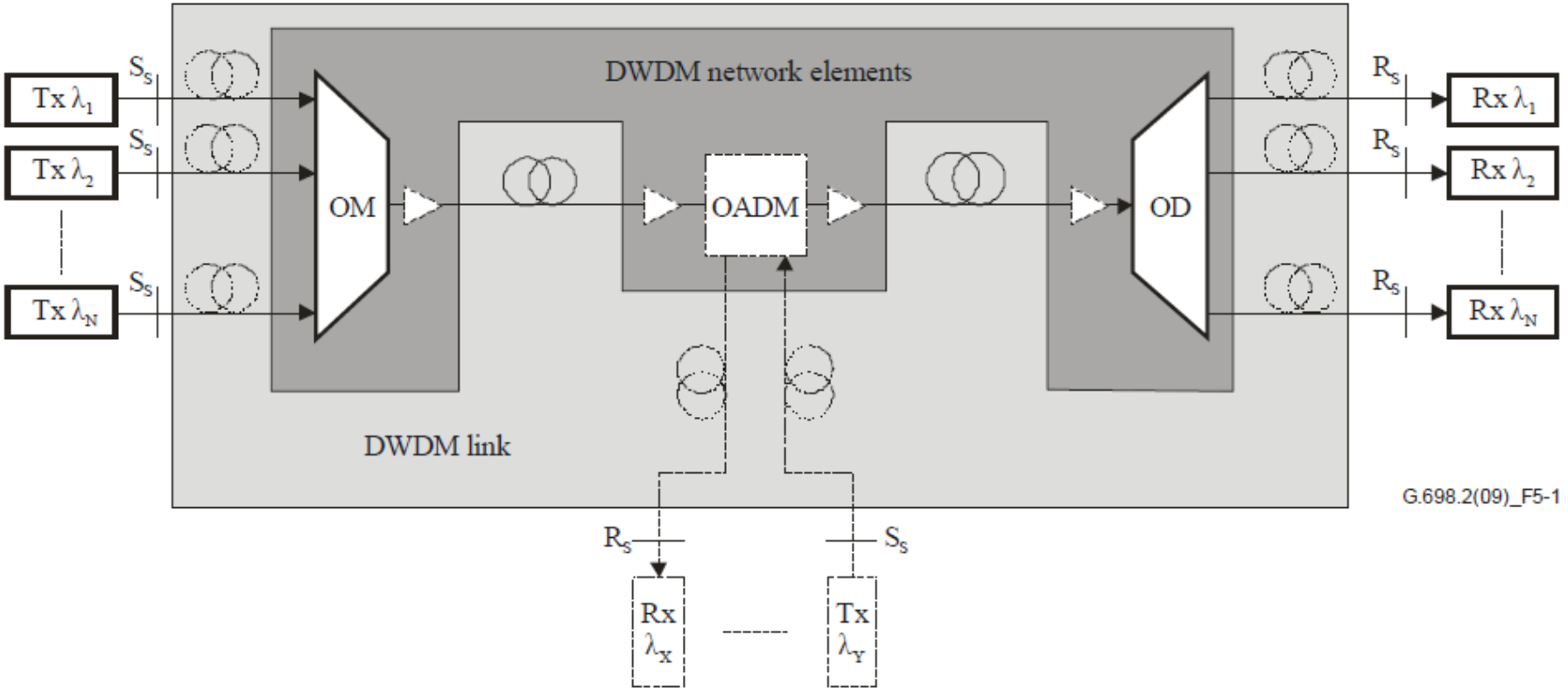


Figure 5-1 – Linear "black link" approach

Black link specification methodology

From in-force Recommendation ITU-T G.698.2:

- Applications are defined using optical interface parameters at the single-channel connection points between optical transmitters and the optical multiplexer, as well as between optical receivers and the optical demultiplexer in the DWDM system.
- It uses a methodology which does not specify the details of the optical link, e.g., the maximum fibre length, explicitly.
- This means that optical interface parameters for only (single-channel) optical tributary signals are specified.
- Additional specifications are provided for the black link parameters, such as residual chromatic dispersion, ripple and polarization mode dispersion.

New elements in black link methodology

Transmitter parameters:

- Maximum spectral excursion (fitting the passband through the DWDM network)
- Maximum transmitter (residual) dispersion OSNR penalty (probably not needed for coherent).
- Some new parameter to describe quality of transmitter in case of coherent.

Link parameters:

- Maximum ripple (describing the flatness of the passband and the minimum passband)
- Max & Min (residual) chromatic dispersion
- Maximum DGD
- Maximum inter-channel crosstalk at output demux
- Maximum interferometric crosstalk at output demux
- Maximum optical path OSNR penalty
- ***Loss is NOT specified, because the link contains OAs***

Receiver parameters:

- Minimum OSNR & Receiver OSNR tolerance

Maximum spectral excursion in G.698.2

Maximum spectral excursion is the maximum acceptable difference between the nominal central frequency of the channel and the –x dB points of the transmitter spectrum furthest from the nominal central frequency measured at Tx output.

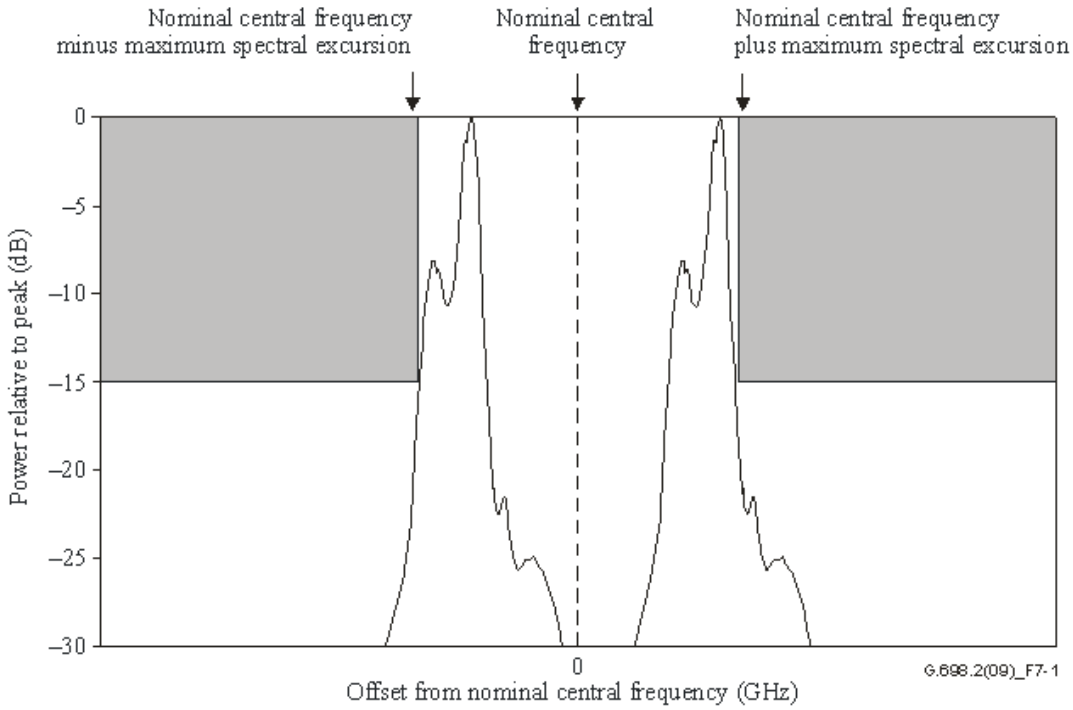


Figure 7-1 – Illustration of maximum spectral excursion

For 2.5G and 10G NRZ signals

Maximum ripple in G.698.2

The ripple (of a DWDM device) is defined in [ITU-T G.671]. In G.698.2 it is applied to the entire black link from Tx output to the corresponding Rx input. For any optical channel, it is the peak-to-peak difference in insertion loss between the input and output ports of the black link for that channel in the frequency range of the central frequency of the channel ± the maximum spectral excursion.

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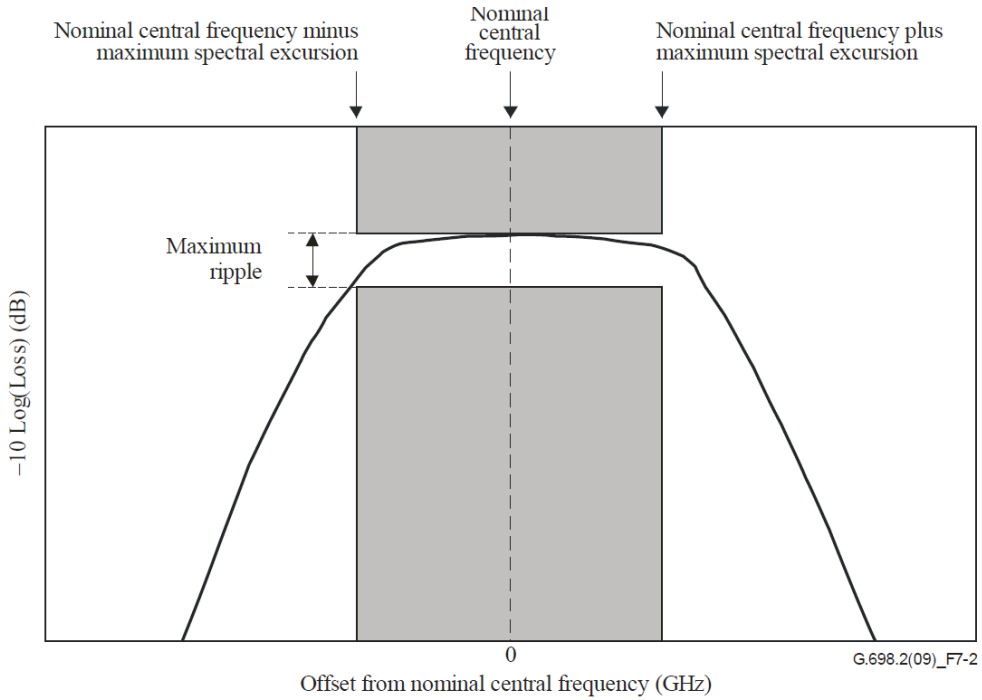

How to establish black link characteristics?

- For the 2.5Gb/s and 10Gb/s applications in in-force G.698.2 as a first step so-called “terms of reference” were agreed upon:
  - Distances in the range of 200 – 450 km.
  - Link including 2 – 3 OADMs, not excluding 6 – 7.
- These terms of reference were ***used*** to define the optical interface parameters.
- The terms of reference are specifically **NOT** a part of the Recommendation.
- If those would be included, then every end-user would have wanted to see his configuration included in the recommendation.
- And then as “someone” would say “you are doomed”.
- The black link methodology provides flexibility for a variety of users.

Extending to coherent 100G & 200G

- Irrespective whether it's an option 1 or 2 configuration, a new metric for the transmitter quality will be necessary, because a pure amplitude related parameter like TDP or TDECQ can no longer be used.
  - The work done in ITU-T Q6/15 for 100G DP-QPSK, establishing EVM_{RMS} as a suitable Tx metric, can form a basis for other bit rates, modulation formats and constellation complexities.
- Specifically for option 2, with a (black) DWDM link between Tx and Rx, parameter definitions and associated parameter values for maximum spectral excursion and ripple will be necessary, appropriate for the bit rate under consideration and associated modulation format.
  - The work done in ITU-T Q6/15 for 100G DP-QPSK can form a good starting point.

Further impact of option 2.

- The DWDM network in between DWDM compatible Tx and Rx :
  - Will have its own (proprietary) link engineering rules;
  - Is likely to have its own equipment practice, especially if it's not co-located with the "end" equipment;
  - May have a separate management system;
  - May need the engagement of 3rd parties to deploy and operate it.

For discussion in b10k Study Group

- Are there more options than the 2 listed in this presentation?

- The b10k Study Group will need to understand which of these options is being proposed before being able to make appropriate decisions on the proposal “to introduce objectives for 100 & 200 Gb/s 40-80km interfaces with appropriate support for DWDM systems”

Q & A?

Thanks