Optical Multi-Vendor Interoperable Specifications in ITU-T SG15/Q6

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Coherent Multi-Vendor Interoperable Interfaces

Broadband/Network | ITU-T Standards | Quality/Performance | Standards

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ITU delivers the first multi-vendor interoperable 100G coherent line interfaces

100 Gbit/s DP-DQPSK optical interface specifications (**OTL4.4-SC or FOIC1.4-SC tributary signals), for**:

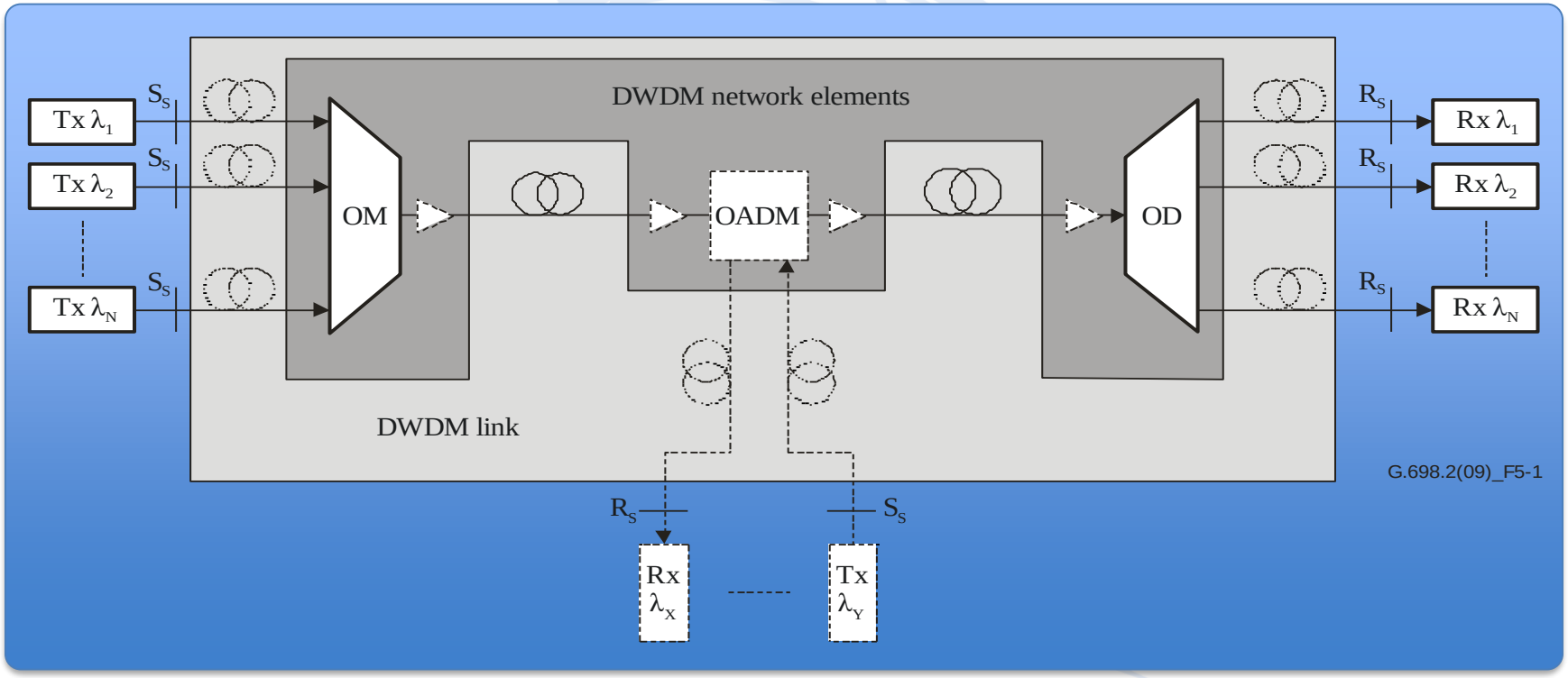
- **200 – 450 km** distances, **2 – 3 OADMs**, not precluding 6 – 7;
- **80 km** distances, not precluding 120 km;
- 50GHz and 100GHz minimum channel spacing in G.652, G.653, G.655 optical fiber types.

What's so special about this work in ITU-T?

- **Specifications** and **optical parameter definitions** on basis of established "**black link" methodology**:
  - Flexibility for users, supporting a variety of applications without defining its details.
  - Removes complexity of engineering of non-linear performance of the black link (gain tilt OAs, Cross-Phase mixing, Four Wave Mixing, etc.) from the standard.
- **Coherent multi-vendor interoperability** by defining the **quality of an optical signal, with the data encoded in-phase and quadrature, using the 'Error Vector Magnitude':**
  - The metric defines the **quality of a transmitter**, a consideration **fundamental to multi-vendor interoperability**.
- **"black link" methodology is also adopted in IEEE 802.3 100GBASE-ZR in P802.3ct, 400GBASE-ZR in P802.3cw and OIF 400ZR project.**

The black link approach “in G.698.2”

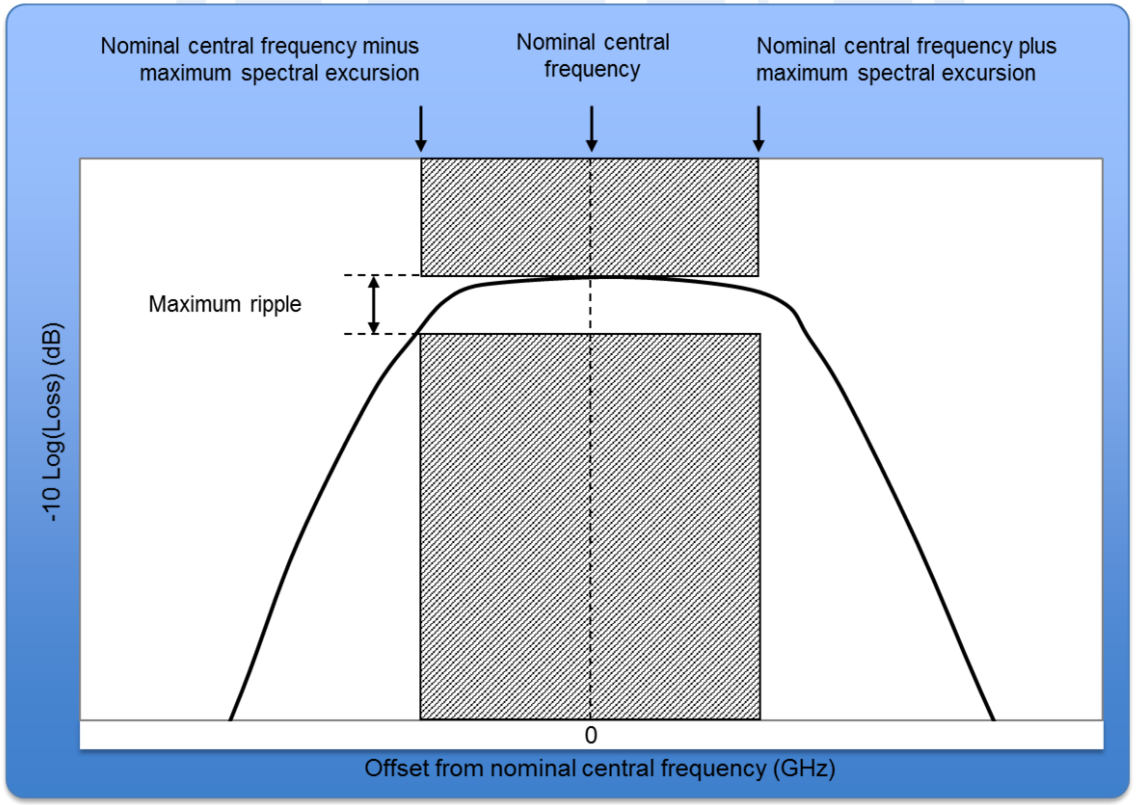
- **The “amplified” multi-channel DWDM network (from input to the optical multiplexer to the output of the optical demultiplexer) is kept intentionally “BLACK”:**



- **S_s** and **R_s** are **single-channel reference points** at the **DWDM network element** tributary **input** and **output**, respectively;
- **Every path from S_s to its corresponding R_s must comply with the parameter values of the application code.**

How to characterize the Black Link?

- **Define the transfer characteristics only.**
- **Maximum Ripple specification as** main "**tunnel**" parameter:
  - "**Tunnel flatness**";
  - "**Tunnel width**", with 1-to-1 relation with the **transmitter maximum spectral excursion**.



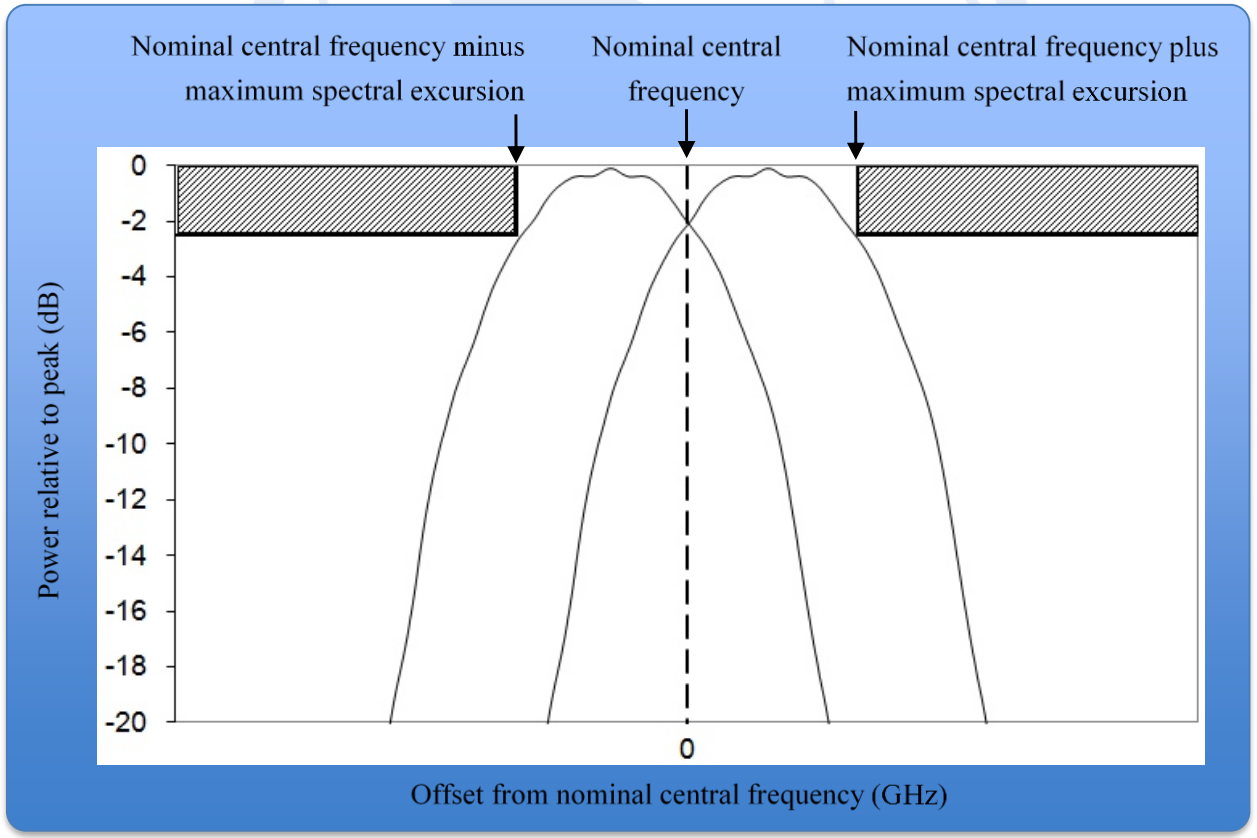
Coherent Multi-Vendor Interoperable Interfaces

- In **multi-vendor scenarios** it is **crucial to unambiguously separate the burden on the transmitter from the burden on the receiver**.

- **ITU-T Q6/15 has developed a set of Transmitter Quality Metrics via multi-company contributions and extensive testing efforts:**
  - **Maximum spectral excursion** (placing limits on the passband through the DWDM network);
  - **And specifically for coherent optical interfaces, Maximum Error Vector Magnitude (EVM_{RMS}),** including the definition of a reference receiver leading to EVM_{RMS} testing.

Maximum Spectral Excursion

Maximum spectral excursion is the maximum acceptable **difference between the nominal central frequency of the channel** and **the –2.5 dB points (for 100 Gbit/s DP-DQPSK application codes) of the transmitter spectrum furthest from the nominal central frequency** measured at **Tx output**.



Error Vector Magnitude

The EVM is the length of the vector - at the detected symbol location - **which connects the I/Q reference-signal vector to the I/Q measured-signal vector.**

$$EVM[n] = \sqrt{I_{err}^2[n] + Q_{err}^2[n]}$$

where: n = symbol index

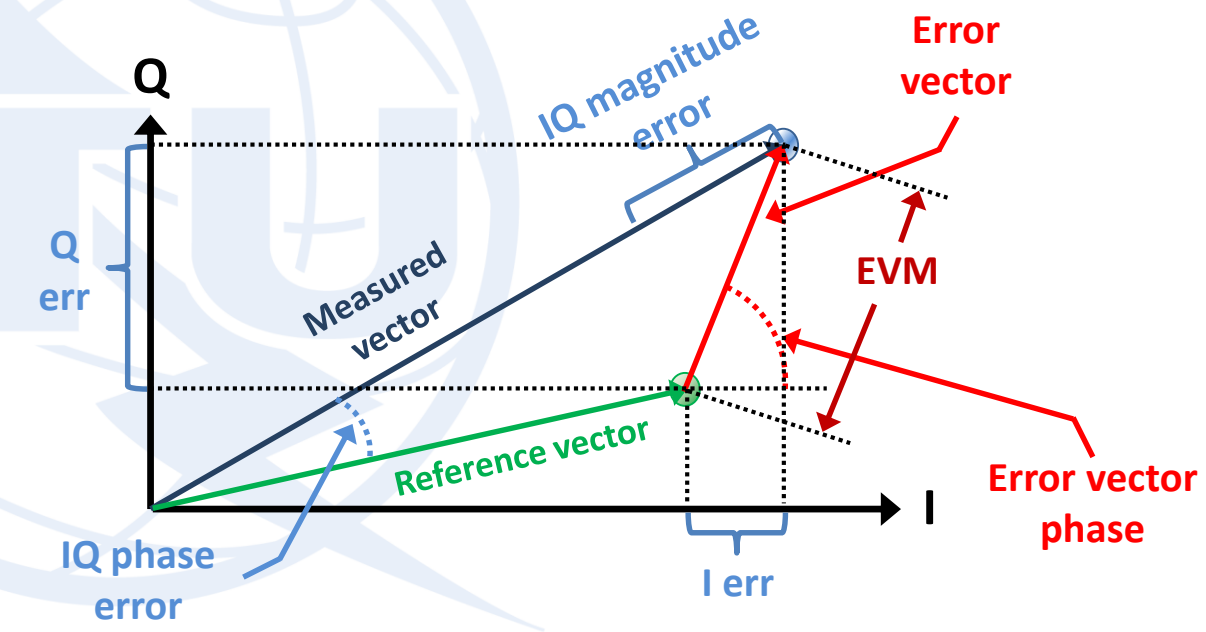
$$I_{err} = I_{meas} - I_{ref}$$

$$Q_{err} = Q_{meas} - Q_{ref}$$

$$EVM_{RMS} = \frac{\sqrt{\frac{1}{N}\sum_{n=1}^{N} EVM^2[n]}}{|A|}$$

where: N= number of EVM points

A= normalization factor



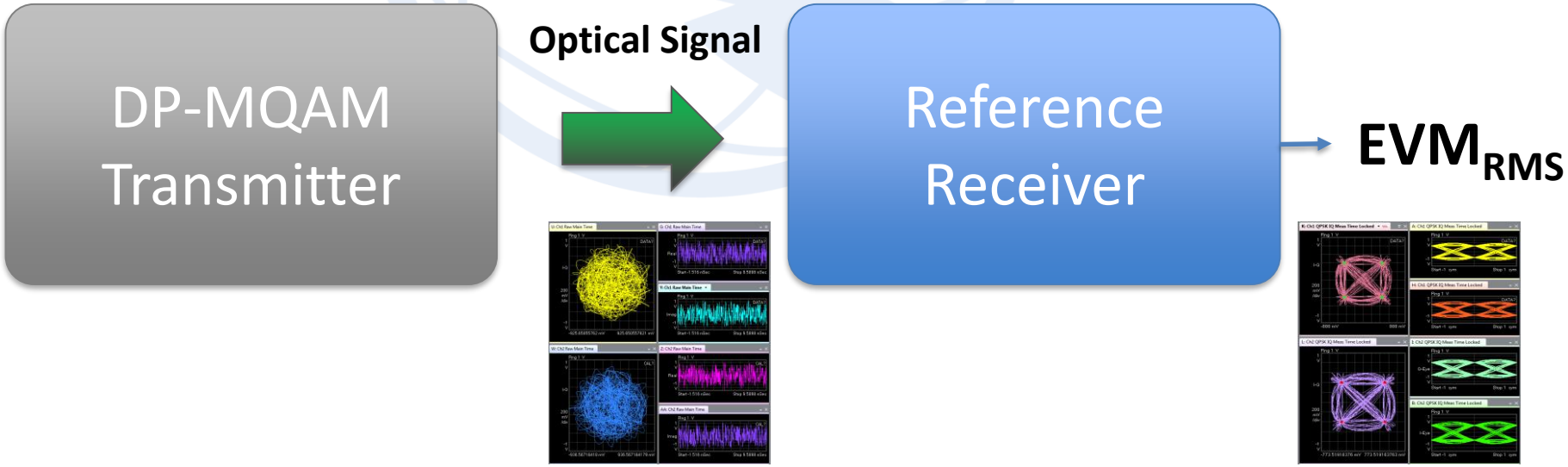
If **EVM = 0** then we have measured an **ideal signal**!

How to Measure EVM_{RMS}?

The **EVM_{RMS} metric** should consistently **predict the OSNR penalty due to a variety of transmitter impairments**.

Since the **EVM_{RMS}** is **measured from a "clean" constellation plot**, a **reference receiver with defined processing blocks** is needed for consistent results.

Multi-company testing on **representative hardware was required** to support the **definition of appropriate parameters and associated values for multi-vendor interoperable optical specs**.



Work in progress

Specifications for **200 Gbit/s and 400 Gbit/s** applications based on **DP-QPSK and DP-16QAM** in a **further revision of G.698.2**.

Terms of reference:

- **80 km distances, not precluding 120 km, without OADMs;**
- **200 – 450 km distances, for 3 – 4 OADMs, not precluding 6 – 7.**

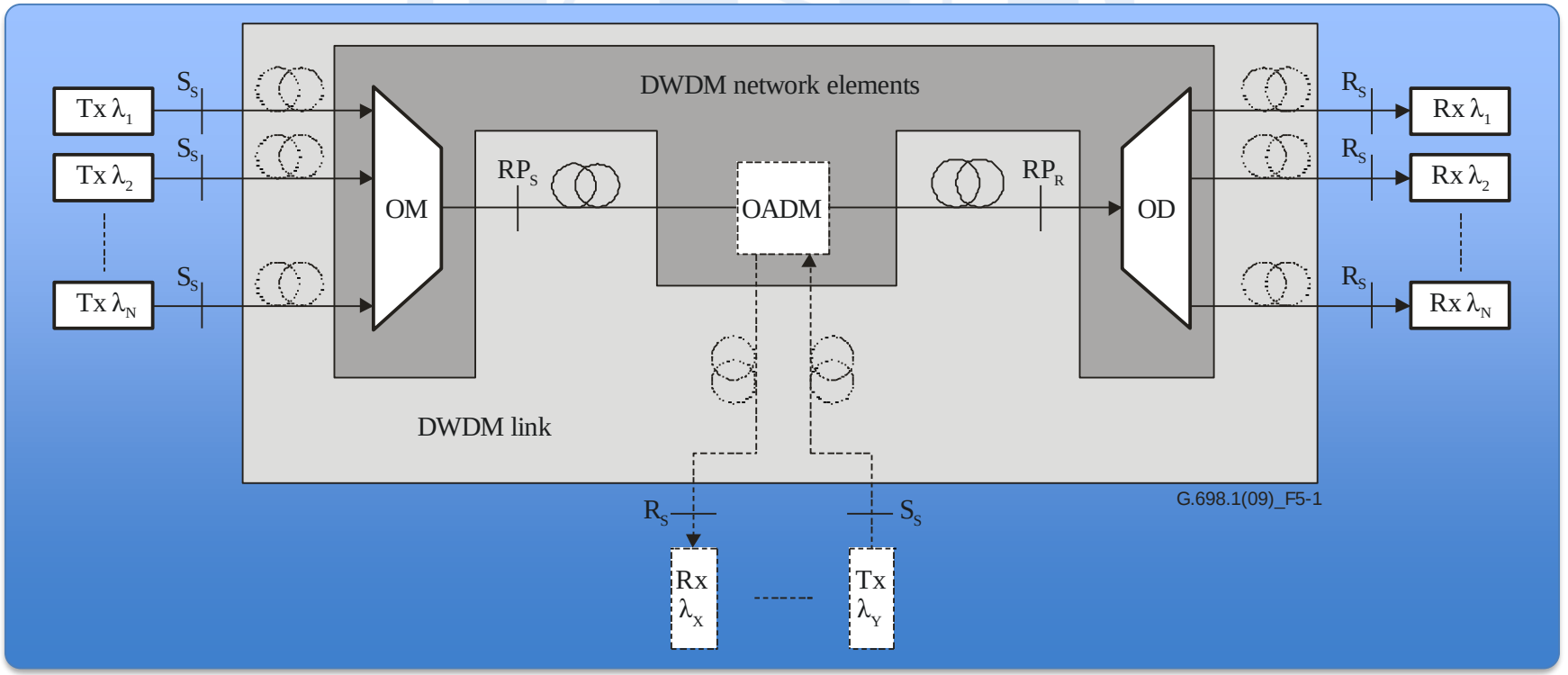
IM/DD Multi-Vendor Interoperable Interfaces

G.698.1: Multichannel DWDM applications with single-channel optical interfaces

Unamplified DWDM systems primarily intended for **metro applications**.

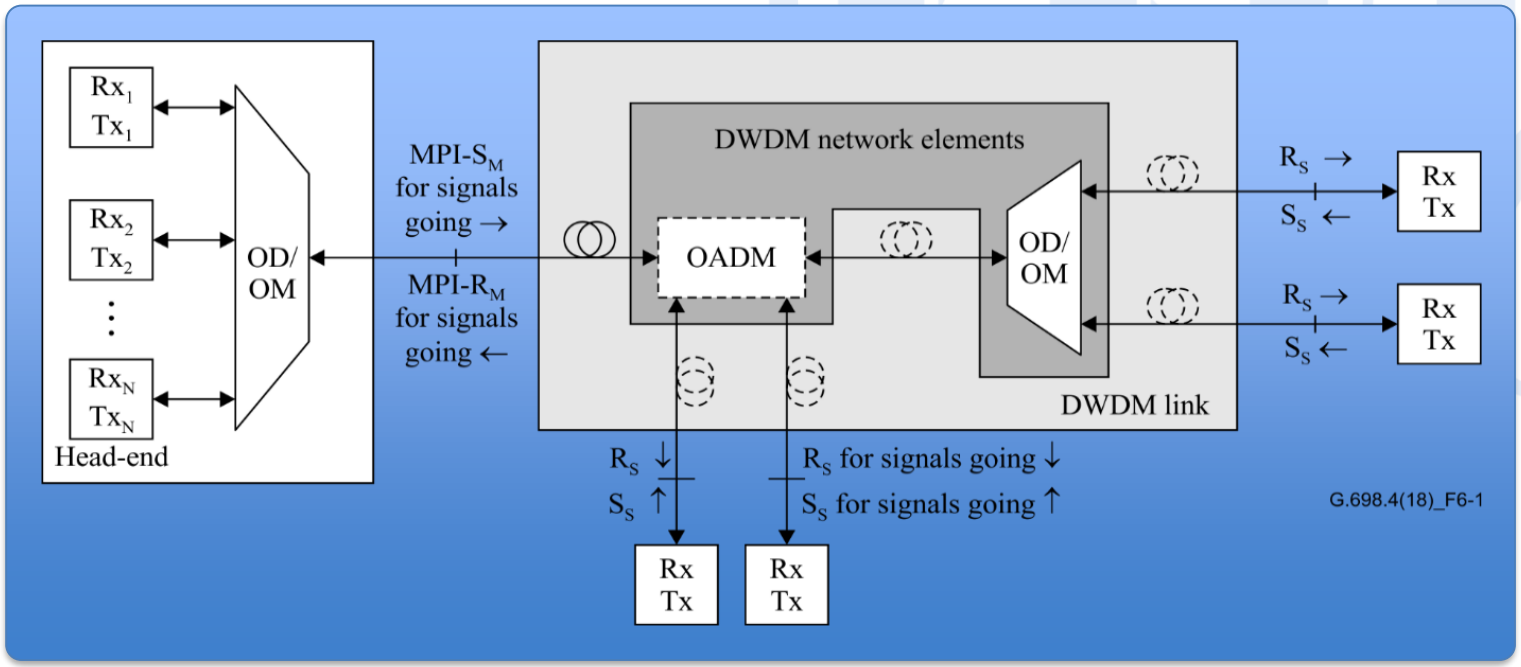
Specification including the following features:

- Bit rate of signal channel: **up to 10 Gbit/s**;
- Channel frequency spacing: **50 GHz and 100 GHz**;
- Transmission distance**: 30 km – 80 km**.



G.698.4: Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces

Bidirectional DWDM systems, primarily intended for **metro applications**. The **tail-end equipment (TEE) transmitters have the capability to automatically adapt their DWDM channel frequency to the optical demultiplexer/optical multiplexer (OD/OM) or OADM port they are connected to using feedback from the head-end equipment (HEE) via the head-to-tail message channel (HTMC).**



Specification including the following features:

- Bit rate of signal channel: **up to 10 Gbit/s**;
- Channel frequency spacing: **50 GHz and 100 GHz**;
- Transmission distance**: up to 20 km**;
- Capacity: **up to 40 bidirectional channels**.

Work in progress

G.698.1: specifications for **25 Gbit/s NRZ** at channel frequency spacing of **50GHz and 100GHz** for **unamplified transmission distance up to 10 km**.

G.698.4: specifications for **25 Gbit/s NRZ** at channel frequency spacing of **50GHz and 100GHz** for transmission **distance up to 10 km** and with up to **20 bidirectional channels**.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