

Recommendation

ITU-T G.698.4 (05/2025)

SERIES G: Transmission systems and media, digital systems and networks

Transmission media and optical systems characteristics –
Characteristics of optical systems

Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces

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Recommendation ITU-T G.698.4

Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces

Summary

Recommendation ITU-T G.698.4 provides optical parameter values for physical layer interfaces of dense wavelength division multiplexing (DWDM) systems primarily intended for metro applications, where the tail-end transmitters have the capability to automatically adapt their DWDM channel frequency to the optical demultiplexer/optical multiplexer (OD/OM) or optical add-drop multiplexer (OADM) port they are connected to. Applications are defined using optical interface parameters and values for single-channel and multichannel interfaces of multichannel DWDM optical systems in point-to-point applications. This Recommendation uses a system architecture comprising a head-end, connecting to the tail-end equipment (TEE) through a black link. The head end houses a set of transmitters and receivers and an OD/OM. A single bidirectional fibre is used to connect the head-end to the black link OD/OM or OADM. The connection between the OD/OM/OADM and the TEE is also bidirectional. This version of the Recommendation includes DWDM applications at 10 Gbit/s and 25 Gbit/s with minimum channel frequency spacing of 50 GHz and 100 GHz, respectively.

History *

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Recommendation ITU-T G.698.4

Multichannel bi-directional DWDM applications with port agnostic single-channel optical interfaces

1 Scope

The purpose of this Recommendation is to provide optical interface specifications towards the realization of transversely compatible bidirectional dense wavelength division multiplexing (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 optical add/drop multiplexer (OADM) port that they are connected to using feedback from the head-end equipment (HEE) via the head-to-tail message channel (HTMC).

This Recommendation defines and provides values for optical interface parameters of point-to-point DWDM applications on single-mode optical fibres through the use of the "black link" approach with both of the propagation directions sharing the same optical fibre end-to-end.

For the applications in this version of the Recommendation, the black link does not contain optical amplifiers.

This Recommendation describes bidirectional DWDM systems that include the following features:

- minimum channel frequency spacing: 50 GHz for 10 Gbit/s and 100 GHz for 25 Gbit/s;
- bit rate of signal channel: 10 Gbit/s and 25 Gbit/s;
- maximum transmission distance: 20 km for 10 Gbit/s and 10 km for 25 Gbit/s;
- maximum capacity: 40 bidirectional channels at 10 Gbit/s and 20 bidirectional channels at 25 Gbit/s.

Specifications are organized according to application codes.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [[ITU-T G.652](#)] Recommendation ITU-T G.652 (2024), *Characteristics of a single-mode optical fibre and cable*.
- [[ITU-T G.664](#)] Recommendation ITU-T G.664 (2012), *Optical safety procedures and requirements for optical transmission systems*.
- [[ITU-T G.671](#)] Recommendation ITU-T G.671 (2025), *Transmission characteristics of optical components and subsystems*.
- [[ITU-T G.694.1](#)] Recommendation ITU-T G.694.1 (2020), *Spectral grids for WDM applications: DWDM frequency grid*.
- [[ITU-T G.698.1](#)] Recommendation ITU-T G.698.1 (2023), *Multichannel DWDM applications with single-channel optical interfaces*.

- [[ITU-T G.709.4](#)] Recommendation ITU-T G.709.4/Y.1331.4 (2020), *OTU25 and OTU50 short-reach interfaces*.
- [[ITU-T G.957](#)] Recommendation ITU-T G.957 (2006), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.
- [[ITU-T G.959.1](#)] Recommendation ITU-T G.959.1 (2024), *Optical transport network physical layer interfaces*.
- [IEC 60825-1] IEC 60825-1:2014, *Safety of laser products – Part 1: Equipment classification and requirements*.
- [IEC 60825-2] IEC 60825-2:2021, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCSs)*.
- [IEEE 802.3] IEEE 802.3-2022, *IEEE Standard for Ethernet*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 Terms defined in [ITU-T G.671]:

- channel insertion loss;
- channel spacing;
- dense wavelength division multiplexing (DWDM);
- differential group delay;
- reflectance;
- ripple.

3.1.2 Term defined in [ITU-T G.694.1]:

- frequency grid.

3.1.3 Terms defined in [ITU-T G.957]:

- receiver sensitivity;
- transverse compatibility.

3.1.4 Terms defined in [ITU-T G.959.1]:

- optical tributary signal;
- optical tributary signal class non-return to zero (NRZ) 10G;
- optical tributary signal class NRZ 25G.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BER	Bit Error Ratio
DWDM	Dense Wavelength Division Multiplexing
HEE	Head-End Equipment

HTMC	Head-to-Tail Message Channel
LOL	Loss of Lock
LOS	Loss of Signal
MPI-R _M	Multichannel reference point at the head-end aggregate input
MPI-S _M	Multichannel reference point at the head-end aggregate output
NRZ	Non-Return to Zero
OADM	Optical Add-Drop Multiplexer
OD	Optical Demultiplexer
OM	Optical Multiplexer
RPM	Remote Performance Monitoring
R _S	Single-channel reference point at the DWDM network element tributary output
S _S	Single-channel reference point at the DWDM network element tributary input
TEE	Tail-End Equipment
THMC	Tail-to-Head Message Channel
TOM	Type of Message

5 Conventions

None.

6 Classification of optical interfaces

6.1 Applications

This Recommendation provides the physical layer parameters and values for single-channel and multichannel interfaces of dense wavelength division multiplexing (DWDM) multichannel optical systems in physical point-to-point single fibre applications where the tail-end transmitters have the capability to automatically adapt their DWDM channel frequency. These DWDM systems are primarily intended to be used in metropolitan area networks for a variety of clients, services and protocols.

The specification method in this Recommendation uses a "black link" approach, which means that optical interface parameters for only (single-channel) optical tributary signals are specified at the tail-end equipment (TEE). Additional specifications are provided for the black-link parameters such as maximum attenuation, chromatic dispersion, ripple and polarization mode dispersion. This approach enables transverse compatibility at the single-channel point using a direct wavelength-multiplexing configuration and transverse compatibility at the head-end multichannel point as shown in Figure 6-1.

6.2 Reference points

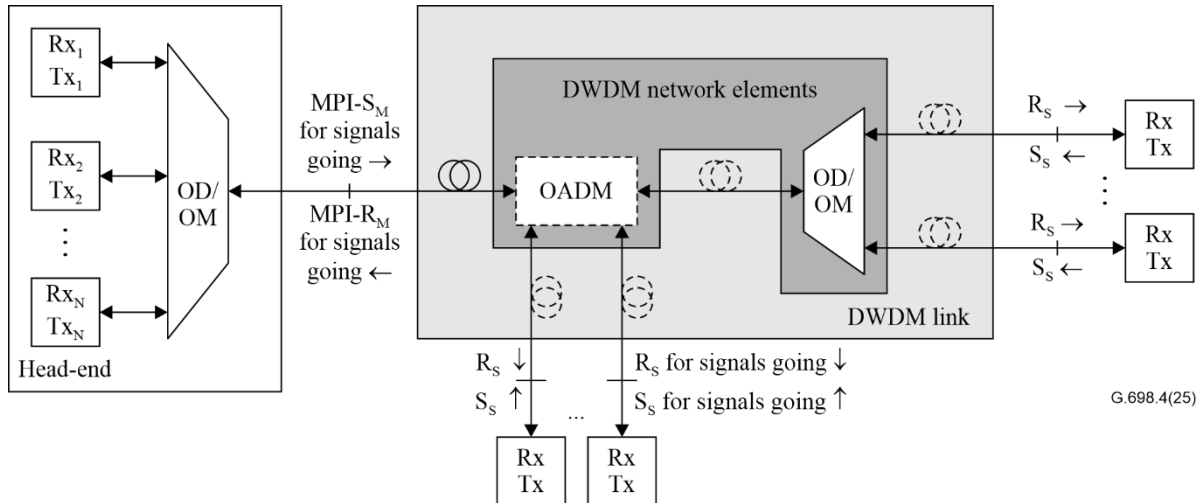


Figure 6-1 – Linear "black link" approach

The system architecture comprises a head-end, connecting to the TEE through a black link. The head-end houses a set of transmitters and receivers and an OD/OM. A single bidirectional fibre is used to connect the head-end to the passive OD/OM as well as optional optical add-drop multiplexer (OADMs). Connection between OD/OM or OADMs and TEE is also bidirectional. The OD/OM is considered to be part of the black link. The TEE transmitters have the capability to automatically adapt their DWDM channel frequency to the OD/OM or OADM port they are connected to.

The reference points in Figure 6-1 are defined as follows:

- MPI-S_M is a multichannel reference point at the head-end aggregate output;
- MPI-R_M is a multichannel reference point at the head-end aggregate input;
- S_S is a single-channel reference point at the TEE output;
- R_S is a single-channel reference point at the TEE input.

At the MPI-S_M interface, multichannel data signals are transmitted by the head-end.

At the R_S interface a single channel data signal passes through towards the TEE.

At the S_S interface, a single channel signal is transmitted by the TEE whose wavelength is appropriate to that of the connected OD/OM or OADM port.

At the MPI-R_M interface, a multichannel signal is received by the head-end.

6.3 Nomenclature

The application code notation is constructed as follows:

ADcW-y-tz-o-rpm

where:

- AD: is the indicator of metro DWDM applications with port agnostic TEE.
- c: is the channel spacing in GHz.
- W: is a letter indicating the span distance, such as:
 - S indicating short-haul;
- y: indicates the highest class of optical tributary signal supported:
 - 2 indicating non-return to zero (NRZ) 10G;

- 9 indicating NRZ 25G.
 - t: indicates the configuration supported by the application code. In the current version of this Recommendation, the only value used is:
 - D indicating that the black link does not contain any optical amplifiers.
 - z: indicates the fibre types. In the current version of this Recommendation, the only value used is:
 - 2 indicating [ITU-T G.652] fibre.
 - o: is an indicator of the operation method of the TEE transmitter, which can take the following values:
 - f indicating transmitters that do not have the ability to tune to the required TEE central frequency on its own but need feedback from the head-end equipment (HEE). In this version of the Recommendation this operation method is only used for 10G application codes.
 - r indicating TEE transmitters that tune to a central frequency value communicated by the HEE. Once the central frequency value has been set, no further feedback is needed from the HEE. This operation method will be referred to hereinafter as remote tuning.
 - s indicating transmitters that do have the ability to tune to the required TEE central frequency without this being communicated to them by the HEE. Once the central frequency value has been set, no further feedback is needed from the HEE. This operation method will be referred to hereinafter as self-tuning. No self-tuning capable application codes are defined in the current version of this Recommendation.
- rpm: when present, indicates application code supporting remote performance monitoring (RPM) mechanisms.

7 Transverse compatibility

This Recommendation specifies parameters in order to enable transverse (i.e., multivendor) compatible line systems for point-to-point applications at single-channel reference points S_S and R_S and multichannel reference points $MPI-S_M$ and $MPI-R_M$ of the black link.

The single-channel reference point at the DWDM network element tributary input (S_S) and single-channel reference point at the DWDM network element tributary output (R_S) are intended to make multiple tributary interfaces of tunable DWDM TEEs transversely compatible with the head-end. In this case, tributary signal transmitter ($T_x \lambda_i$) and receiver ($R_x \lambda_i$) pairs may be from different vendors. Similarly, multichannel reference points $MPI-S_M$ and $MPI-R_M$ are intended to make black link and head-end equipment transversely compatible. Thus, TEE, black link and head-end equipment (HEE) suppliers are not necessarily the same.

Transverse (multivendor) compatibility is enabled for reference points $MPI-S_M$ to R_S and S_S to $MPI-R_M$ of the black link having exactly the same application code.

8 Parameter definitions

The parameters in Table 8-1 are defined at the interface points and the definitions are provided in the clauses below.

Table 8-1 – Physical layer parameters for multichannel bi-directional DWDM applications

Parameter	Units	For HEE to TEE defined in:	For TEE to HEE defined in:
General information			
Minimum channel spacing	GHz	8.1.1	8.1.1
Bit-rate/line coding of optical tributary signals	–	8.1.2	8.1.2
Maximum bit-error ratio	–	8.1.3	8.1.3
Fibre type	–	8.1.4	8.1.4
Interface at point S_S or MPI-S_M			
Maximum mean channel output power	dBm	8.2.1	8.2.1
Minimum mean channel output power	dBm	8.2.1	8.2.1
Maximum mean total output power	dBm	8.2.2	NA
Minimum central frequency	THz	8.2.3	8.2.3
Maximum central frequency	THz	8.2.3	8.2.3
Maximum spectral excursion	GHz	8.2.4	8.2.4
Maximum laser drift	GHz/10 min	8.2.5	8.2.5
Minimum channel extinction ratio	dB	8.2.6	8.2.6
Eye mask	–	8.2.7	8.2.7
Bit rate of message channel	kbit/s	8.2.8	8.2.8
Maximum frequency tolerance of message channel	ppm	8.2.8	8.2.8
Maximum modulation depth of message channel	%	8.2.9	8.2.9
Minimum modulation depth of message channel	%	8.2.9	8.2.9
Maximum modulation depth of pilot tone during operation	%	NA	8.2.10
Minimum modulation depth of pilot tone during operation	%	NA	8.2.10
Minimum modulation depth of pilot tone during tuning	%	NA	8.2.10
Maximum frequency of pilot tone	Hz	NA	8.2.11
Minimum frequency of pilot tone	Hz	NA	8.2.11
Maximum frequency tolerance of pilot tone	ppm	NA	8.2.11
Minimum frequency spacing of pilot tones	Hz	NA	8.2.11
Maximum combined tolerance of Rx power measurement and Tx power setting at TEE ($\pm$)	dB	NA	8.2.12
Optical path from point MPI-S_M to R_S or S_S to MPI-R_M			
Maximum channel insertion loss	dB	8.3.1	8.3.1
Minimum channel insertion loss	dB	8.3.1	8.3.1
Maximum ripple	dB	8.3.2	8.3.2
Maximum chromatic dispersion	ps/nm	8.3.3	8.3.3
Minimum optical return loss at MPI-S _M or S _S	dB	8.3.4	8.3.4
Maximum discrete reflectance between MPI-S _M and R _S or between S _S and MPI-R _M	dB	8.3.5	8.3.5
Maximum differential group delay	ps	8.3.6	8.3.6
Maximum inter-channel crosstalk at R _S	dB	8.3.7	8.3.7

Table 8-1 – Physical layer parameters for multichannel bi-directional DWDM applications

Parameter	Units	For HEE to TEE defined in:	For TEE to HEE defined in:
Maximum loss difference between HE-to-TE and TE-to-HE direction	dB	8.3.8	8.3.8
Minimum black link channel width	GHz	8.3.9	8.3.9
Interface at point R_s or MPI-R_M			
Maximum mean channel input power	dBm	8.4.1	8.4.1
Minimum mean channel input power	dBm	8.4.1	8.4.1
Maximum mean total input power	dBm	NA	8.4.2
Receiver sensitivity	dBm	8.4.3	NA
Minimum equivalent sensitivity	dBm	NA	8.4.4
Maximum optical path penalty	dB	8.4.5	8.4.5
Maximum reflectance of receiver or optical network element	dB	8.4.6	8.4.6
Maximum mean channel input power during tuning	dBm	NA	8.4.7
Minimum mean channel input power during tuning	dBm	NA	8.4.7

8.1 General information

8.1.1 Minimum channel spacing

The minimum channel spacing is defined in [ITU-T G.698.1].

8.1.2 Bit-rate/line coding of optical tributary signals

The bit-rate/line coding of optical tributary signals is defined in [ITU-T G.959.1].

8.1.3 Maximum bit-error ratio

The maximum bit-error ratio is defined in [ITU-T G.698.1].

8.1.4 Fibre type

Currently, the only single-mode optical fibre type is defined in [ITU-T G.652].

8.2 Interface at point S_s or MPI-S_M

8.2.1 Maximum and minimum mean channel output power

The mean channel output power is defined in [ITU-T G.959.1].

8.2.2 Maximum mean total output power

The maximum mean total output power is defined in [ITU-T G.959.1].

8.2.3 Minimum and maximum central frequency

The central frequency is defined in [ITU-T G.698.1].

For each optical channel, different ranges of frequencies are used in the HE-to-TE and TE-to-HE directions. The channel frequencies in the two directions are paired so that their difference is equal to the minimum value compatible with the frequency ranges.

In application codes AD100S-2-D2-f, AD100S-9-D2-r and AD100S-9-D2-r-rpm the optical channel frequencies are paired according to Table 8-2.

Table 8-2 – Frequency pairing for AD100S-2-D2 and AD100S-9-D2

HE-to-TE	TE-to-HE
194.1	191.5
194.2	191.6
...	...
196	193.4

In application code AD50S-2-D2-f the optical channel frequencies are paired according to Table 8-3.

Table 8-3 – Frequency pairing for AD50S-2-D2

HE-to-TE	TE-to-HE
194.05	191.45
194.1	191.5
...	...
196	193.4

8.2.4 Maximum spectral excursion

The maximum spectral excursion is defined in [ITU-T G.698.1].

8.2.5 Maximum laser drift

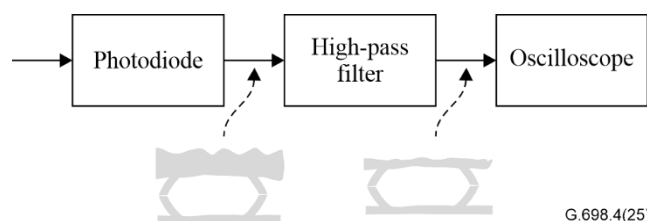
The maximum variation, within a time window of 10 minutes of the centroid of the TEE transmitter frequency averaged over 200 ms. The drift is measured without the frequency control feedback from the HEE.

8.2.6 Minimum channel extinction ratio

The minimum channel extinction ratio is defined in [ITU-T G.698.1].

8.2.7 Eye mask

The eye mask can be measured by means of the set-up given in Figure 8-1. The eye mask and limits for this parameter are found in [ITU-T G.959.1].

**Figure 8-1 – Measurement set-up for the eye mask**

NOTE – The cut-off frequency of the high-pass filter is 280 kHz.

8.2.8 Bit rate of message channel

The bit rate of the message channel that is used to transmit information from the HEE to the TEE or from the TEE to the HEE via envelope modulation of the optical signal.

8.2.9 Minimum and maximum modulation depth of message channel

The modulation depth of the message channel is the difference between the average optical power in the "ones" of the message channel and the average optical power in the "zeros", divided by twice the average optical power.