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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Transmission media and optical systems characteristics – Characteristics of optical systems

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Multichannel seeded DWDM applications with single-channel optical interfaces

Recommendation ITU-T G.698.3

ITU-T

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Recommendation ITU-T G.698.3

Multichannel seeded DWDM applications with single-channel optical interfaces

Summary

Recommendation ITU-T G.698.3 provides optical parameter values for physical layer interfaces of seeded dense wavelength division multiplexing (DWDM) systems primarily intended for metro applications. Applications are defined using optical interface parameters and values for single-channel and multichannel interfaces of seeded DWDM multichannel 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 optical multiplexer and demultiplexer (OD/OM) in addition to a seed signal source. A single bidirectional fibre is used to connect the head-end to the passive OD/OM. Connection between OD/OM and remote TEE is also bidirectional. At the tail-end, all transmitters use a seed signal to lock to the desired transmission wavelength. The initial version of this Recommendation includes seeded DWDM application at 1.25 Gbit/s with 100-GHz channel frequency spacing.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.698.3	2012-02-13	15

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Recommendation ITU-T G.698.3

Multichannel seeded DWDM applications with single-channel optical interfaces

1 Scope

The purpose of this Recommendation is to provide optical interface specifications towards the realization of transversely compatible seeded dense wavelength division multiplexing (DWDM) systems primarily intended for metro applications.

This Recommendation defines and provides values for optical interface parameters of point-to-point seeded DWDM applications (with maximum transmission distance of about 40 km) on single-mode optical fibres through the use of the "black link" approach.

Applications containing amplifiers within the black link are outside the scope of this Recommendation.

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

– Channel frequency spacing: 100 GHz;

– Bit rate of signal channel: up to 1.25 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 (2005), *Characteristics of a single-mode optical fibre and cable*.

[ITU-T G.664] Recommendation ITU-T G.664 (2006), *Optical safety procedures and requirements for optical transport systems*.

[ITU-T G.671] Recommendation ITU-T G.671 (2009), *Transmission characteristics of optical components and subsystems*.

[ITU-T G.691] Recommendation ITU-T G.691 (2006), *Optical interfaces for single-channel STM-64 and other SDH systems with optical amplifiers*.

[ITU-T G.694.1] Recommendation ITU-T G.694.1 (2002), *Spectral grids for WDM applications: DWDM frequency grid*.

[ITU-T G.698.1] Recommendation ITU-T G.698.1 (2009), *Multichannel DWDM applications with single-channel optical interfaces*.

[ITU-T G.709] Recommendation ITU-T G.709/Y.1331 (2009), *Interfaces for the Optical Transport Network (OTN)*.

[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 (2009), *Optical transport network physical layer interfaces*.

[IEC 60825-1] IEC 60825-1 (2007), *Safety of laser products – Part 1: Equipment classification and requirements*.

[IEC 60825-2] IEC 60825-2 (2010), *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*.

3 Terms and 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 Term defined in [ITU-T G.709]:

– completely standardized OTUk (OTUk)

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

– joint engineering

– receiver sensitivity

– transverse compatibility

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

– optical tributary signal

– optical tributary signal class NRZ 1.25G

3.2 Terms defined in this Recommendation

This Recommendation does not define any terms.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BER Bit Error Ratio

BLS Broadband Light Source

DOP Degree of Polarization

DWDM Dense Wavelength Division Multiplexing

MPI-R_M Multichannel reference point at the head-end aggregate input

MPI-S_M Multichannel reference point at the head-end aggregate output

MWS Multi-Wavelength Source

NA	Not Applicable
NRZ	Non-Return to Zero
OD	Optical Demultiplexer
OM	Optical Multiplexer
OTUk	Completely standardized optical channel transport unit – k
RIN	Relative Intensity Noise
R_S	Single-channel reference point at the DWDM network element tributary output
SLED	Super-luminescent Light Emitting Diode
S_S	Single-channel reference point at the DWDM network element tributary input
TEE	Tail-End Equipment
WDM	Wavelength Division Multiplexing

5 Classification of optical interfaces

5.1 Applications

This Recommendation provides the physical layer parameters and values for single-channel and multichannel interfaces of seeded DWDM multichannel optical systems in physical point-to-point applications. 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 also transverse compatibility at the head-end multichannel point as shown in Figure 5-1.

This Recommendation only considers DWDM applications where the black link does not contain optical amplifiers.

5.2 Reference points

Figure 5-1 shows a set of reference points that are defined in this Recommendation.

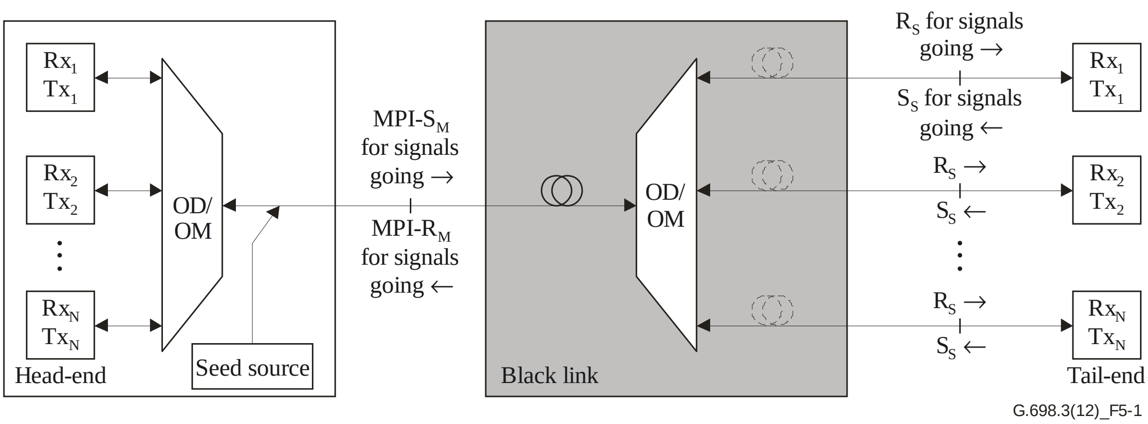


Figure 5-1 – Reference diagram

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 in addition to a seed signal source. The seed source can be implemented in a number of ways. These include pumped Erbium-doped fibre, a super-luminescent light emitting diode (SLED) or a multi-wavelength laser source. A single bidirectional fibre is used to connect the head-end to the passive OD/OM. Connection between OD/OM and remote TEE is also bidirectional. The OD/OM is considered to be part of the black link. The black link does not include any optical amplifiers. At the tail-end, all transmitters use a seed signal to lock to the desired transmission wavelength.

The reference points in Figure 5-1 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 and a broadband seed signal are transmitted by the head-end.

At the R_S interface two types of single channel signals pass through towards the TEE; a data signal and a seed signal to lock the transmission in the tail-end to head-end direction.

At the S_S interface, a single channel signal is transmitted by the TEE whose wavelength is locked to the incoming seed signal.

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

5.3 Nomenclature

The application code identifies the network, implementation, and architectural characteristics of an application.

The application code notation is constructed as follows:

SDcW-ytz

where:

SD is the indicator of Seeded DWDM applications.

c is the channel spacing in GHz.

W is a letter indicating the span distance. In the current version of this Recommendation, the only value used is:

S indicating short-haul;

y indicates the highest class of optical tributary signal supported. In the current version of this Recommendation, the only value used is:

0 indicating NRZ 1.25G;

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;

5.4 Interfaces at the reference points MPI-S_M, MPI-R_M, S_S and R_S

The interfaces described in Tables 8-1 to 8-2 are intended to enable transverse compatibility at the single-channel and multichannel interfaces at the ingress/egress points of the seeded DWDM link (OM, fibre, and OD) as shown in Figure 5-1.

Further requirements related to transverse compatibility can be found in clause 6.

Table 5-1 summarizes the application codes, which are structured according to the nomenclature in clause 5.3.

Application	Short-haul (S)
Type of fibre	ITU-T G.652
Optical tributary signal class NRZ 1.25G	SD100S-0D2

The non-amplified applications in this Recommendation are specified in Tables 8-1 to 8-2.

6 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 approach seeded DWDM systems.

The single-channel reference points S_S and R_S are intended to make multiple tributary interfaces of seeded DWDM TEEs transversely compatible. In this case, tributary signal transmitter (Tx λ_i) and receiver (Rx λ_j) 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 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 black link approach seeded DWDM systems having exactly the same application code.

Co-existence of tributary interfaces with different application codes over the same black link is a matter of joint engineering. Care must be taken, particularly with respect to critical parameters of the interfaces that must be consistent, e.g., S_S output power and MPI-R_M input power, S_S bit rate/line coding and MPI-R_M bit rate/line coding, etc.

7 Parameter definitions

The parameters in Table 7-1 are defined at the interface points, and the definitions are provided in the clauses below.

Table 7-1 – Physical layer parameters for seeded DWDM applications

Parameter	Units	Defined in Table 8-1	Defined in Table 8-2
General information			
Minimum channel spacing	GHz	Clause 7.1.1	Clause 7.1.1
Bit rate/line coding of optical tributary signals	–	Clause 7.1.2	Clause 7.1.2
Maximum bit-error ratio	–	Clause 7.1.3	Clause 7.1.3
Fibre type	–	Clause 7.1.4	Clause 7.1.4

Table 7-1 – Physical layer parameters for seeded DWDM applications

Parameter	Units	Defined in Table 8-1	Defined in Table 8-2
Interface at point S_S or MPI-S_M			
Maximum mean channel output power	dBm	Clause 7.2.1	Clause 7.2.1
Minimum mean channel output power	dBm	Clause 7.2.1	Clause 7.2.1
Minimum central frequency	THz	Clause 7.2.2	Clause 7.2.2
Maximum central frequency	THz	Clause 7.2.2	Clause 7.2.2
Maximum spectral excursion	GHz	Clause 7.2.3	
Minimum channel extinction ratio	dB	Clause 7.2.4	Clause 7.2.4
Eye mask	–	Clause 7.2.5	Clause 7.2.5
Seed source type		Clause 7.2.6	
Maximum power spectral density of the seed signal	dBm/nm	Clause 7.2.7	
Minimum power spectral density of the seed signal	dBm/nm	Clause 7.2.7	
Maximum mean channel output seed signal power	dBm	Clause 7.2.7	
Minimum mean channel output seed signal power	dBm	Clause 7.2.7	
Maximum wavelength of the seed signal	nm	Clause 7.2.8	
Minimum wavelength of the seed signal	nm	Clause 7.2.8	
Maximum degree of polarization of the seed signal	%	Clause 7.2.9	
Optical path from point MPI-S_M to R_S or S_S to MPI-R_M			
Maximum channel insertion loss	dB	Clause 7.3.1	Clause 7.3.1
Minimum channel insertion loss	dB	Clause 7.3.1	Clause 7.3.1
Maximum ripple	dB	Clause 7.3.2	Clause 7.3.2
Minimum channel half width	GHz		Clause 7.3.3
Maximum chromatic dispersion	ps/nm	Clause 7.3.4	Clause 7.3.4
Minimum optical return loss at MPI-S_M or S_S	dB	Clause 7.3.5	Clause 7.3.5
Maximum discrete reflectance between MPI-S_M and R_S or between S_S and MPI-R_M	dB	Clause 7.3.6	Clause 7.3.6
Maximum differential group delay	ps	Clause 7.3.7	Clause 7.3.7
Maximum inter-channel crosstalk at R_S	dB	Clause 7.3.8	
Interface at point R_S or MPI-R_M			
Maximum mean channel input power	dBm	Clause 7.4.1	Clause 7.4.1
Minimum mean channel input power	dBm		Clause 7.4.1
Maximum mean channel seed signal input power	dBm	Clause 7.4.2	
Minimum mean channel seed signal input power	dBm	Clause 7.4.2	
Maximum relative intensity noise	dBc/Hz		Clause 7.4.3
Receiver sensitivity	dBm	Clause 7.4.4	
Minimum equivalent sensitivity	dBm		Clause 7.4.5
Maximum optical path penalty	dB	Clause 7.4.6	Clause 7.4.6
Maximum reflectance of receiver or optical network element	dB	Clause 7.4.7	Clause 7.4.7

7.1 General information

7.1.1 Minimum channel spacing

The minimum nominal difference in frequency between two adjacent channels. All possible tolerances of actual frequencies are considered in clause 7.2.3.

7.1.2 Bit rate/line coding of optical tributary signals

Optical tributary signal class NRZ 1.25G applies to continuous digital signals with non-return to zero line coding, from nominally 622 Mbit/s to nominally 1.25 Gbit/s.

7.1.3 Maximum bit error ratio

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

7.1.4 Fibre type

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

7.2 Interface at point S_S or MPI-S_M

7.2.1 Maximum and minimum mean channel output power

The mean channel output power of each optical channel at reference point MPI-S_M is the average power of a pseudo-random data sequence coupled into the black link. It is given as a range (maximum and minimum) to allow for some cost optimization and to cover allowances for operation under the standard operating conditions, connector degradations, measurement tolerances, and aging effects.

The mean channel output power of each optical channel at reference point S_S is the average power of a pseudo-random data sequence coupled through the black link and measured at MPI-R_M corrected for the minimum value of the insertion loss of the actual black link within the frequency range of the nominal central frequency of the channel ± the minimum channel half width. It is given as a range (maximum and minimum) to allow for some cost optimization and to cover allowances for operation under the standard operating conditions, connector degradations, measurement tolerances, and aging effects.

7.2.2 Minimum and maximum central frequency

The central frequency is the nominal single-channel frequency on which the digital coded information of the particular optical channel is modulated by use of the NRZ line code.

The central frequencies of all channels in the tail-end to head-end direction lie on the frequency grid for the minimum channel spacing given in [ITU-T G.694.1]. The central frequencies of all channels in the head-end to tail-end direction do not lie on the frequency grid for the minimum channel spacing given in [ITU-T G.694.1]. Instead, they are determined by the free spectral range of the cyclic OD/OM device.

The nominal central frequencies of all channels should be greater than or equal to the minimum central frequency and less than or equal to the maximum central frequency.

Note that the value of "c" (speed of light in vacuum) that should be used for converting between frequency and wavelength is 2.99792458×10^8 m/s.

7.2.3 Maximum spectral excursion

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

7.2.4 Minimum channel extinction ratio

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

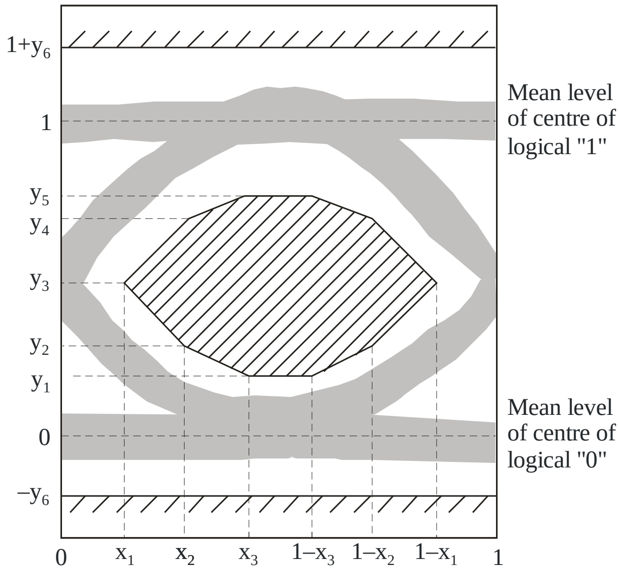
7.2.5 Eye mask

The definition and limits for this parameter for the head-end to tail-end direction are found in [ITU-T G.959.1].

For the tail-end to head-end direction, general transmitter pulse shape characteristics including rise time, fall time, pulse overshoot, pulse undershoot, and ringing, all of which should be controlled to prevent excessive degradation of the receiver sensitivity, are specified in the form of a mask of the transmitter eye diagram at reference point S_S.

The parameters specifying the mask of the TEE transmitter eye diagram are shown in Figure 7-2. For this "ratio" mask, the acceptable ratio of samples inside to outside the hatched area (the "hit ratio") must be met.

The test arrangement and filter tolerances are as specified for STM-64 in Annex A of [ITU-T G.691].



	NRZ 1.25G ratio
x_1	0.25
x_2	0.4
x_3	0.45
y_1	0.2
y_2	0.23
y_3	0.45
y_4	0.67
y_5	0.70
y_6	0.4
Max hit ratio	5×10^{-5}

G.698.3(12)_F7-1

Figure 7-1 – Mask of the eye diagram for the tail-end to head-end direction

7.2.6 Seed source type

The head-end houses a seed signal source. Possible seed signal sources are divided into two categories: BLS and MWS. Sources such as pumped Erbium-doped fibre and super-luminescent light emitting diode (SLED) are categorised as broadband light sources (BLS). A BLS is required to meet the maximum and minimum power spectral density of the seed signal parameters. Multi-wavelength sources (MWS) that produce a discrete line per channel are required to meet the maximum and minimum mean channel output seed signal power parameters.

7.2.7 Maximum and minimum power spectral density and power of the seed signal

For a broadband light source (BLS), the power spectral density of the seed signal is defined as the mean power of the seed signal per nm of bandwidth at the MPI-S_M interface. It is given as a range (maximum and minimum) to allow for some cost optimization of the source and to cover allowances for operation under the standard operating conditions, connector degradations, measurement tolerances, and aging effects. The resolution bandwidth of the measurement should be between one and two times the minimum channel spacing. The measured power should be corrected for the resolution bandwidth of the measurement for any resolution bandwidth other than 1 nm.

For a multi-wavelength source (MWS), the maximum and minimum mean channel output seed signal power of each optical channel at reference point MPI-S_M is the average power coupled into the black link. It is given as a range (maximum and minimum) to allow for some cost optimization and to cover allowances for operation under the standard operating conditions, connector degradations, measurement tolerances, and aging effects.

7.2.8 Maximum and minimum wavelength of the seed signal

The maximum and minimum wavelengths of the seed signal define the range of wavelengths over which the other requirements on the seed signal must be met.

7.2.9 Maximum degree of polarization of the seed signal

Degree of polarization (DOP) is a quantity used to describe the portion of an optical signal which is polarized. It is given by the ratio of the power in the polarized part of the signal to the total power. A perfectly polarized signal has a DOP of 100%, whereas a completely unpolarized signal has a DOP of 0%. A signal which is partially polarized, and therefore can be represented by a superposition of a polarized and unpolarized component, will have a DOP somewhere in between 0% and 100%. This parameter is required to be met on a per channel basis using the reference filter as specified in Annex B of [ITU-T G.959.1].

7.3 Optical path parameters from MPI-S_M to R_S or S_S to MPI-R_M

7.3.1 Minimum and maximum channel insertion loss

The minimum and maximum channel insertion loss for the head-end to tail-end direction is defined as in [ITU-T G.698.1].

For the tail-end to head-end direction, the channel insertion loss is defined in G.671. For any optical channel it is the minimum (or maximum) reduction in optical power 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 minimum channel half width.

Insertion loss specifications are assumed to be worst-case values including losses due to the OD/OM splices, connectors, optical attenuators (if used) or other passive optical devices, and any additional cable margin to cover allowances for:

1) future modifications to the cable configuration (additional splices, increased cable lengths, etc.);
2) fibre cable performance variations due to environmental factors; and
3) degradation of any connectors, optical attenuators or other passive optical devices between points S_S and MPI-R_M, if used.

7.3.2 Maximum ripple

The maximum ripple for the head-end to tail-end direction is defined as in [ITU-T G.698.1].

For the tail-end to head-end direction, the ripple (of a DWDM device) is defined in [ITU-T G.671]. It is applied to the entire black link from reference point S_S to reference point MPI-R_M. 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 nominal central frequency of the channel ± the minimum channel half width. This is illustrated in Figure 7-2.

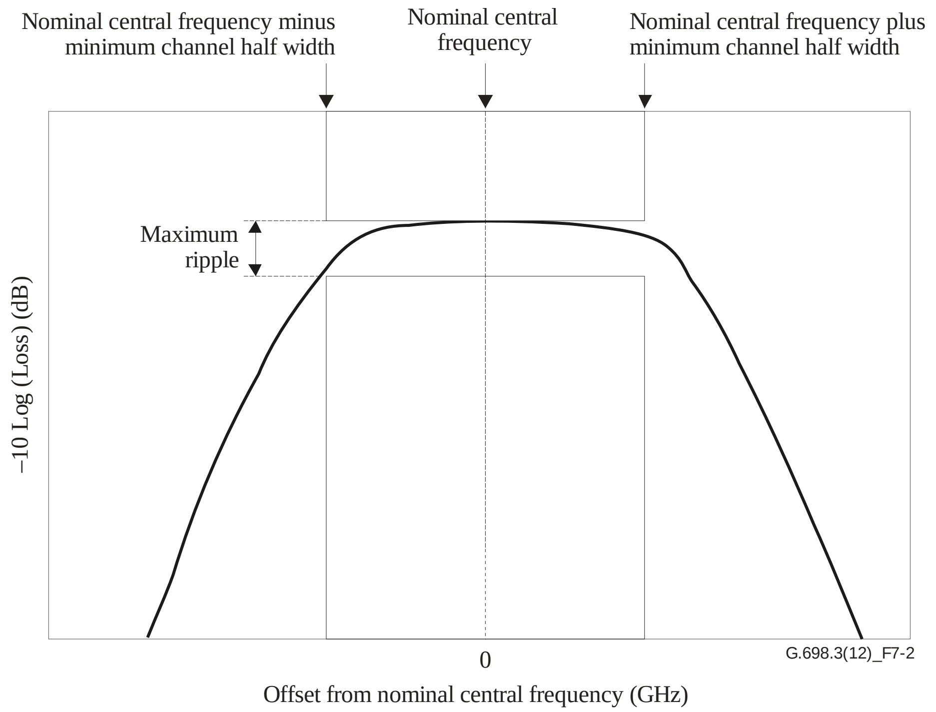


Figure 7-2 – Illustration of maximum ripple for tail-end to head-end direction

7.3.3 Minimum channel half width

This parameter defines the range of frequencies over which the channel insertion loss and ripple specifications must be met for the tail-end to head-end direction. See clauses 7.3.1 and 7.3.2.

7.3.4 Maximum chromatic dispersion

The maximum chromatic dispersion is defined as in [ITU-T G.698.1].

7.3.5 Minimum optical return loss at MPI-S_M or S_S

The minimum optical return loss at MPI-S_M or S_S is defined as in [ITU-T G.698.1].

7.3.6 Maximum discrete reflectance between MPI-S_M and R_S or between S_S and MPI-R_M

The maximum discrete reflectance between MPI-S_M and R_S or between S_S and MPI-R_M is defined as in [ITU-T G.698.1].

7.3.7 Maximum differential group delay

The maximum differential group delay is defined as in [ITU-T G.698.1].

7.3.8 Maximum inter-channel crosstalk

The maximum inter-channel crosstalk is defined as in [ITU-T G.698.1].

7.4 Interface at point R_S or MPI-R_M

7.4.1 Maximum and minimum mean channel input power

The maximum and minimum value of the average power of a pseudo-random data sequence received at MPI-R_M or R_S to achieve the specified maximum BER of the application code.

NOTE – The minimum mean channel input power at MPI-R_M must be higher than the minimum equivalent sensitivity by the value of the maximum optical path penalty.

7.4.2 Maximum and minimum mean channel seed signal input power

The channel seed signal input power is the mean power of the received seed signal at R_S. It is given as a range (maximum and minimum) to allow for performance and cost optimization and to cover allowances for operation under the standard operating conditions, connector degradations, measurement tolerances, fibre loss and aging effects.

7.4.3 Maximum relative intensity noise

The relative intensity noise (RIN) is defined as the ratio of the amplitude noise of an optical source relative to the average optical power produced by that source. The unit of RIN is dBc/Hz. It is measured using the reference filter as specified in Annex B of [ITU-T G.959.1] with all the references to maximum spectral excursion replaced with the minimum channel half width.

7.4.4 Receiver sensitivity

The receiver sensitivity is defined as in [ITU-T G.698.1].

7.4.5 Minimum equivalent sensitivity

The minimum equivalent sensitivity is defined as in [ITU-T G.959.1].

7.4.6 Maximum optical path penalty

The maximum optical path penalty is defined as in [ITU-T G.698.1].

7.4.7 Maximum reflectance of receiver or optical network element

The maximum reflectance of receiver is defined as in [ITU-T G.698.1].

The maximum reflectance of optical network element is defined as in [ITU-T G.959.1].

8 Parameter values

The physical layer parameters and values are given in Tables 8-1 and 8-2.

Table 8-1 – Physical layer parameters and values for class NRZ 1.25G, 97.15-GHz-spaced applications (head-end to tail-end)

Parameter	Units	SD100S-0D2
General information		
Minimum channel spacing	GHz	97.15
Bit rate/line coding of optical tributary signals	–	NRZ 1.25G
Maximum bit-error ratio	–	10^{-12}
Fibre type	–	ITU-T G.652
Interface at point MPI-S_M		
Maximum mean channel output power	dBm	–7
Minimum mean channel output power	dBm	–13
Minimum central frequency	THz	186.143
Maximum central frequency	THz	190.70905
Maximum spectral excursion	GHz	±20
Minimum channel extinction ratio	dB	10

Table 8-1 – Physical layer parameters and values for class NRZ 1.25G, 97.15-GHz-spaced applications (head-end to tail-end)

Parameter	Units	SD100S-0D2	
Eye mask	–	NRZ 10G Ratio large per [ITU-T G.959.1]	
Seed source type		BLS	MWS
Maximum power spectral density of the seed signal	dBm/nm	4	–
Minimum power spectral density of the seed signal	dBm/nm	–0.5	–
Maximum mean channel output seed signal power	dBm	–	1
Minimum mean channel output seed signal power	dBm	–	–4
Maximum wavelength of the seed signal	nm	1566	
Minimum wavelength of the seed signal	nm	1527	
Maximum degree of polarization of the seed signal	%	10	
Optical path from point MPI-S_M to R_S			
Maximum channel insertion loss	dB	14	
Minimum channel insertion loss	dB	3	
Maximum ripple	dB	2	
Maximum chromatic dispersion	ps/nm	883	
Minimum optical return loss at MPI-S_M	dB	32	
Maximum discrete reflectance between MPI-S_M and R_S	dB	–35	
Maximum differential group delay	ps	NA	
Maximum inter-channel crosstalk	dB	–15	
Interface at point R_S			
Maximum mean channel input power	dBm	–10	
Maximum mean channel seed signal input power	dBm	–2	
Minimum mean channel seed signal input power	dBm	–18	
Receiver sensitivity	dBm	–28	
Maximum optical path penalty	dB	1	
Maximum reflectance of receiver	dB	–27	

Table 8-2 – Physical layer parameters and values for class NRZ 1.25G, 100-GHz-spaced applications (tail-end to head-end)

Parameter	Units	SD100S-0D2
General information		
Minimum channel spacing	GHz	100
Bit rate/line coding of optical tributary signals	–	NRZ 1.25 G
Maximum bit-error ratio	–	10^{-12}
Fibre type	–	G.652
Interface at point S_S		
Maximum mean channel output power	dBm	2.5
Minimum mean channel output power	dBm	–2.5
Minimum central frequency	THz	191.5
Maximum central frequency	THz	196.2
Minimum channel extinction ratio	dB	10
Eye mask	–	NRZ 1.25G Ratio
Optical path from point S_S to MPI-R_M		
Maximum channel insertion loss	dB	14
Minimum channel insertion loss	dB	3
Maximum ripple	dB	2
Minimum channel half width	GHz	20
Maximum chromatic dispersion	ps/nm	773
Minimum optical return loss at S_S	dB	32
Maximum discrete reflectance between S_S and MPI-R_M	dB	–35
Maximum differential group delay	ps	NA
Interface at point MPI-R_M		
Maximum mean channel input power	dBm	–0.5
Minimum mean channel input power	dBm	–16.5
Maximum relative intensity noise	dBc/Hz	–111
Minimum equivalent sensitivity	dBm	–18.5
Maximum optical path penalty	dB	2.0
Maximum reflectance of optical network element	dB	–27

9 Optical safety considerations

See [ITU-T G.664], [IEC 60825-1] and [IEC 60825-2] for optical safety considerations.

Appendix I

Derivation of off-grid channel frequencies

(This appendix does not form an integral part of this Recommendation.)

A characteristic of an AWG is the periodicity of the frequencies routed from the common port to a given output port. This periodicity is called the free spectral range (FSR). The FSR is commonly specified for a centre channel of the AWG. Due to the varying channel spacings in adjacent bands, the FSR differs as a function of the output port number, as illustrated in Figure I.1, where the channel spacings $\Delta f_L < \Delta f_C < \Delta f_S$.

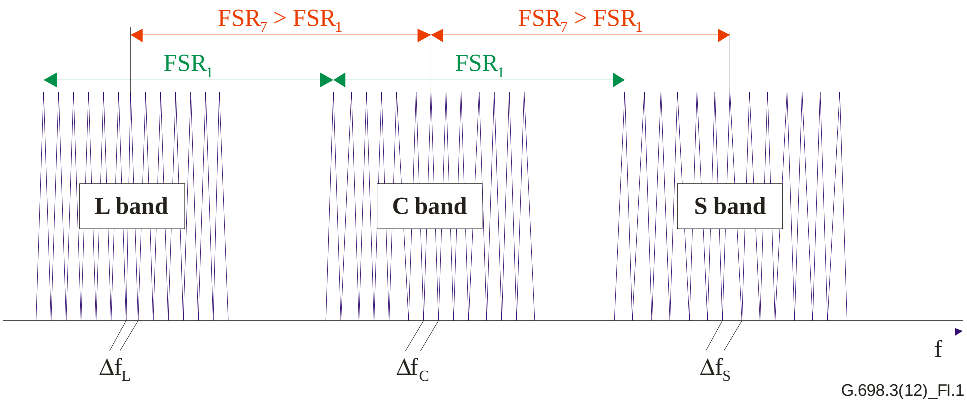


Figure I.1 – Illustration of FSR and channel spacing in a cyclic AWG

The reference channel in the order M is defined at $f_{0,M}$ = 193.9 THz + M × FSR. M is a positive or negative integer including 0. The centre frequency of channel 'n' in the refractive order M for a nominal channel spacing CS, which (linearly) changes with refractive order, is defined to be

$$f_{n,M} = 193.9 \text{ THz} + M \times FSR + n \times CS$$

Here, 'n' is a positive or negative integer including 0. Due to the limited spectral range of each refractive order, n is limited. In this Recommendation $-24 \leq n \leq 23$ for the 100 GHz spaced application codes is used. The FSR used in this Recommendation corresponds to 5425.4 GHz, measured at the channels with nominal frequencies 193.9 THz and 188.4746 THz.

The main reference channel is defined in the centre of the refractive order M = 0 at $f_{0,0}$ = 193.9 THz. This Recommendation uses refractive order 0 for the tail-end to head-end directions and refractive order –1 for the head-end to tail-end direction. Therefore, the reference channel in order –1 is at $f_{0,-1}$ =188.4746 THz. Based on minimum channel spacing of 100 GHz, the minimum central frequency in the tail-end to head-end direction corresponds to $f_{-24,0}$ = 191.5 THz and the maximum central frequency corresponds to $f_{23,0}$ = 196.2 THz. Based on minimum channel spacing (i.e., CS(M = –1)) of 97.15 GHz, the minimum central frequency in the head-end to tail-end direction corresponds to $f_{-24,-1}$ = 186.143 THz and the maximum central frequency corresponds to $f_{23,-1}$ = 190.70905 THz.

The FSR(n=0) is a function of the index contrast ratio of the material used in the construction of the AWG. The value of FSR(n=0) = 5425.4 GHz is based on 1.5% index contrast ratio.

Bibliography

[b-ITU-T G-Sup.39] ITU-T G-series Recommendations – Supplement 39 (2008), *Optical system design and engineering considerations*.

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