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

Transmission media characteristics – Characteristics of optical components and subsystems

Optical interfaces for intra-office systems

ITU-T Recommendation G.693

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ITU-T Recommendation G.693

Optical interfaces for intra-office systems

Summary

This Recommendation provides parameters and values for optical interfaces of single channel intra-office systems of nominal 10 Gbit/s and 40 Gbit/s aggregate bit rate. Applications are specified with target distances of 0.6 and 2 km and various loss budgets for G.652, G.653 and G.655 fibres.

Source

ITU-T Recommendation G.693 was prepared by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 29 November 2001.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

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.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation G.693

Optical interfaces for intra-office systems

1 Scope

The purpose of this Recommendation is to provide optical interface specifications to enable transverse (multi-vendor) compatibility of nominal 10 Gbit/s and 40 Gbit/s aggregate bit rate intra-office systems for link distances up to 2 km. This Recommendation defines links using optical fibres according to ITU-T Recs. G.652, G.653 and G.655.

Parallel interface specifications may be included in future revisions.

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.

– ITU-T Recommendation G.652 (2000), *Characteristics of a single-mode optical fibre cable*.

– ITU-T Recommendation G.653 (2000), *Characteristics of a dispersion-shifted single-mode optical fibre cable*.

– ITU-T Recommendation G.655 (2000), *Characteristics of a non-zero dispersion shifted single-mode optical fibre cable*.

– ITU-T Recommendation G.691 (2000), *Optical interfaces for single channel STM-64, STM-256 systems and other SDH systems with optical amplifiers*.

– ITU-T Recommendation G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy*.

– ITU-T Recommendation G.959.1 (2001), *Optical transport network physical layer interfaces*.

3 Terms and definitions

3.1 Definitions

This Recommendation define the following term:

3.1.1 Optical tributary signal class NRZ 40G

Applies to continuous digital signals with non-return to zero line coding, from nominally 9.9 Gbit/s to nominally 43.02 Gbit/s. In the case of OTN optical tributary signals, NRZ 40G includes a signal with OTU3 bit rate according to ITU-T Rec. G.709.

3.2 Terms defined in other Recommendations

This Recommendation uses terms defined in ITU-T Rec. G.709:

– Completely standardised OTUk (OTUk).

This Recommendation uses terms defined in ITU-T Rec. G.959.1:

– Optical tributary signal class NRZ 10G (NRZ 10G).

4 Abbreviations and acronyms

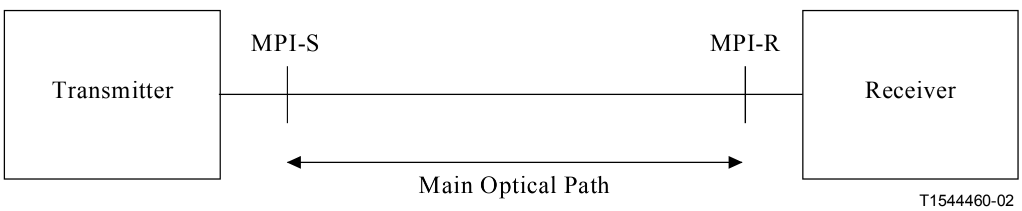
This Recommendation uses the following abbreviations:

ASE	Amplified Spontaneous Emission
BER	Bit Error Ratio
DGD	Differential Group Delay
EX	Extinction Ratio
ffs	For Further Study
MLM	Multi-Longitudinal Mode
MPI	Main Path Interface
MPN	Mode Partition Noise
NA	Not Applicable
NRZ	Non-Return to Zero
ORL	Optical Return Loss
PMD	Polarization Mode Dispersion
PRBS	Pseudo Random Binary Sequence
RMS	Root Mean Square
SDH	Synchronous Digital Hierarchy
SLM	Single-Longitudinal Mode
SMSR	Side Mode Suppression Ratio
VSR	Very Short Reach
WDM	Wavelength Division Multiplex

5 Classification of optical interfaces

5.1 Applications

This Recommendation defines optical interfaces for single-channel intra-office systems for link distances up to 2 km. These interface descriptions are intended to enable transverse (multivendor) compatibility. Figure 1 illustrates a system of the type considered in this Recommendation, and shows the reference points used to specify optical interface parameters.



Note – The Main Optical Path includes fibre and connectors, and may include other passive optical devices such as photonic cross-connects.

Figure 1/G.693 – Optical link example showing reference points defined in this Recommendation

Parameters are specified for the transmitter at point MPI-S, for the receiver at point MPI-R, and for the main optical path between points MPI-S and MPI-R.

Maximum values of chromatic dispersion for the G.652 fibre applications in this Recommendation are obtained from the target distance and operating wavelength range, using Figure A.2/G.957. Maximum values of chromatic dispersion for G.653 fibre applications are calculated as the product of target distance and 3.3 ps/nm·km, except for the VSR2000-2L3 application, where the value is set to equal the value for the VSR2000-2L2 application. Maximum values of chromatic dispersion for G.655 fibre applications are derived from ITU-T Rec. G.655 using the target distances of the respective applications, except for the VSR2000-2L5 application, where the value is set to equal the value for the VSR2000-2L2 application.

The main optical path for systems described in this Recommendation may include passive optical devices, e.g. photonic cross-connects, which introduce significant attenuation. Thus values of maximum attenuation may not be inferred from the target distances of applications. In this Recommendation attenuation categories are used to distinguish among applications which have the same source and fibre type and target distance, and are intended for the same signal class, but have different values of maximum attenuation. Four attenuation categories are defined, with maximum attenuation values of 4 dB, 6 dB, 12 dB and 16 dB, respectively. A fifth category is defined (with a maximum attenuation value ffs) in case the maximum attenuation value provided by the H category is too low to cover all applications.

This Recommendation includes applications with nominal 40 Gbit/s aggregate bit rate for loss category R. It is expected that as 40 Gbit/s technology matures, applications for loss category L will be specified in addition.

5.2 Nomenclature

Applications in this Recommendation are distinguished by application codes. Each code indicates the target distance, highest class of optical tributary signal supported, attenuation category, and source and fibre type of the associated application.

Application codes have the following structure:

– W-yAz

where:

W indicates target distance:

– VSR600, VSR1000 and VSR2000, indicating target distances of 0.6 km, 1 km and 2 km, respectively.

y indicates highest class of optical tributary signal supported:

– 2 indicating NRZ 10G;
– 3 indicating NRZ 40G.

A indicates attenuation category:

– R indicating maximum attenuation of 4 dB.
– L indicating maximum attenuation of 6 dB.
– M indicating maximum attenuation of 12 dB.
– H indicating maximum attenuation of 16 dB.
– V indicating maximum attenuation of ffs dB.

The V category has been introduced in case the maximum attenuation value provided by the H category is too low to cover all applications.

z indicates the source and fibre type:

– 1 indicating nominally 1310 nm sources on G.652 fibre;

– 2 indicating nominally 1550 nm sources on G.652 fibre;

– 3 indicating nominally 1550 nm sources on G.653 fibre;

– 5 indicating nominally 1550 nm sources on G.655 fibre.

Tables 1 and 2 summarize the application codes described in this Recommendation.

Table 1/G.693 – Classification of optical interfaces with 0.6 km target distance based on application and showing application codes

Target distance[a)]	0.6 km		
Attenuation category[a)]	R	M	
Source nominal wavelength (nm)	1310	1310	1550
Type of fibre	G.652	G.652	G.652 G.653 G.655
Application codes for Optical tributary signal class NRZ 10G	VSR600-2R1	VSR600-2M1	VSR600-2M2 VSR600-2M3 VSR600-2M5
Application codes for Optical tributary signal class NRZ 40G	–	–	–
[a)] Target distances and attenuation categories are for classification and not for specification.			

Table 2/G.693 – Classification of optical interfaces with 2 km target distance based on application and showing application codes

Target distance[a)]	2 km					
Attenuation category[a)]	R		L	M		H
Source nominal wavelength (nm)	1310	1550	1550	1310	1550	1550
Type of fibre	G.652	G.652 G.653 G.655	G.652 G.653 G.655	G.652	G.652 G.653 G.655	G.652 G.653 G.655
Application codes for Optical tributary signal class NRZ 10G	VSR2000-2R1	–	VSR2000-2L2 VSR2000-2L3 VSR2000-2L5	–	–	–
Application codes for Optical tributary signal class NRZ 40G	VSR2000-3R1	VSR2000-3R2 VSR2000-3R3 VSR2000-3R5		VSR2000-3M1	VSR2000-3M2 VSR2000-3M3 VSR2000-3M5	VSR2000-3H2 VSR2000-3H3 VSR2000-3H5
[a)] Target distances and attenuation categories are for classification and not for specification.						

6 Parameter definitions

All parameter values are worst-case values, assumed to be met over the range of standard operating conditions (i.e. temperature and humidity ranges), and they include ageing effects. The parameters are specified relative to an optical section design objective of a Bit Error Ratio (BER) not worse than 10^{-12} for any combination of parameters within the ranges given in the Tables for each specified system. Achieving this BER objective shall not require the application of forward error correction.

The optical line coding used for system interfaces in this Recommendation is binary Non-Return to Zero (NRZ).

6.1 System operating wavelength range

The operating wavelength range is the maximum allowable range for source wavelength. Within this range, the source wavelength can be selected for different fibre-related impairments**.** The receiver must have the minimum operating wavelength range that corresponds to the maximum allowable range for the source wavelength.

The operating wavelength range of fibre optic transmission systems is basically determined by the attenuation and dispersion characteristics of the various fibre and source types. A detailed discussion of these aspects can be found in ITU-T Rec. G.957.

NOTE – When a wavelength-fixed or tuneable filter to eliminate Amplified Spontaneous Emission (ASE) is used before the receiver, the operating wavelength band may be limited, and the transverse compatibility may not be guaranteed.

6.2 Transmitter

6.2.1 Source type

Depending on attenuation/dispersion characteristics and hierarchical level of each application code, feasible transmitter devices include multi-longitudinal mode (MLM) lasers and single-longitudinal mode (SLM) lasers. For each of the applications, this Recommendation indicates a nominal source type. It is understood that the indication of a nominal source type in this Recommendation is not a requirement and that SLM devices can be substituted for any application showing MLM as the nominal source type without any degradation in system performance.

6.2.2 Spectral characteristics

6.2.2.1 Maximum RMS width

The maximum Root Mean Square (RMS) width or the standard deviation σ (in nm) of the spectral distribution of a Multi-Longitudinal Mode (MLM) laser considers all laser modes, which are not more than 20 dB down from the peak mode. Only a system with an MLM laser at 1310 nm requires this specification.

6.2.2.2 Maximum –20 dB width

The maximum –20 dB spectral width (in nm) of an SLM laser is specified by the maximum full width of the central wavelength peak, measured –20 dB down from the maximum amplitude of the central wavelength under standard operating conditions.

6.2.2.3 Side mode suppression ratio

The Side Mode Suppression Ratio (SMSR) is defined as the ratio of the largest peak of the total source spectrum to the second largest peak. The spectral resolution of the measurement shall be better (i.e. the optical filter bandwidth shall be less) than the maximum spectral width of the peak, as defined above. The second largest peak may be next to the main peak or far removed from it.

The SMSR specification is intended to minimise the occurrence of BER degradations due to Mode Partition Noise (MPN). Since MPN is a transient effect with low probability, SMSR measurements on PRBS or continuous signals may underestimate the MPN. The SMSR specification is relevant only to SLM laser sources.

6.2.3 Maximum mean output power

The maximum value of the average power of a pseudo-random data sequence coupled into fibre by the transmitter.

6.2.4 Minimum mean output power

The minimum value of the average power of a pseudo-random data sequence coupled into fibre by the transmitter.

6.2.5 Extinction ratio

The extinction ratio (EX) is defined as:

$$EX = 10 * \mathrm{Log}_{10}(A/B)$$

In the above definition of EX, A is the average optical power level at the centre of a logical "1" and B is the average optical power level at the centre of a logical "0". The convention adopted for optical logic levels is:

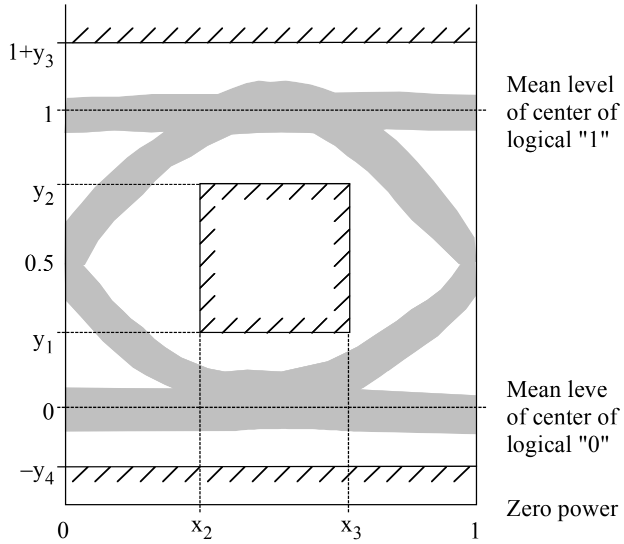
– emission of light for a logical "1";

– no emission for a logical "0".

6.2.6 Eye pattern mask

In this Recommendation, 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 point MPI-S. For the purpose of an assessment of the transmit signal, it is important to consider not only the eye opening, but also the overshoot and undershoot limitations. The parameters specifying the mask of the transmitter eye diagram are shown in Figure 2.

Acceptable transmitter eye diagrams must avoid crossing any of the hatched lines. The test arrangement is as specified for STM-64 in Annex A/G.691. Filter tolerances for the NRZ 10G optical reference receiver are as specified for STM-64 in Annex A/G.691. Filter tolerances for a NRZ 40G optical reference receiver are ffs.



	NRZ 10G 1310 nm region	NRZ 10G 1550 nm region	NRZ 40G
x_3–x_2	0.2	0.2	0.2
y_1	0.25	0.25	0.25
y_2	0.75	0.75	0.75
y_3	0.4	0.25	0.25
y_4	0.25	0.25	0.25

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NOTE – x_2 and x_3 of the rectangular eye mask need not be equidistant with respect to the vertical axes at 0 UI and 1 UI.

Figure 2/G.693 – Mask of the eye diagram for the optical transmit signal

6.3 Optical path

To ensure system performance for each of the applications considered in Table 1, it is necessary to specify attenuation and dispersion characteristics of the optical path between points MPI-S and MPI-R.

6.3.1 Maximum attenuation

The maximum path attenuation where the system in question operates under end-of-life conditions at a BER of 10^{-12} (or as given by the application code), under worst-case transmit-side signal and dispersion. Attenuation specifications are assumed to be worst-case values including losses due to splices, connectors, optical attenuators (if used), other passive optical devices, e.g. photonic cross-connect, and any additional cable margin to cover allowances for degradation of any connectors, optical attenuators or other passive optical devices between points MPI-S and MPI-R, if used.

6.3.2 Minimum attenuation

The minimum path attenuation that allows the system in question, operating under worst case transmit-side conditions, to achieve a BER no worse than 10^{-12} (or as given by the application code.

6.3.3 Dispersion

6.3.3.1 Maximum chromatic dispersion

This parameter defines the maximum uncompensated absolute value of the main path chromatic dispersion that the system shall be able to tolerate. The required maximum dispersion tolerance of the systems is set to a value equal to the target distance times 20 ps/km·nm for G.652 fibre, and 3.3 ps/nm·km for G.653 fibre in the 1550 nm region, as well as for G.652 fibre and an operating wavelength range of 1290 nm to 1330 nm. The required maximum dispersion tolerance of systems with operating wavelength of 1530 nm to 1565 nm for G.655 fibre is set to a value equal to the target distance times 10 ps/km·nm. These are considered worst-case dispersion values for the relevant fibre types.

The maximum chromatic dispersion value includes contributions from fibre and all other elements present in the optical path. In the case that these passive optical devices introduce additional chromatic dispersion, the achievable link distance may be reduced. Alternatively an application with a higher chromatic dispersion tolerance may be used to overcome this restriction.

The allowed penalty for the optical path considers all deterministic effects due to chromatic dispersion as well as the penalty due to the maximum differential group delay.

6.3.3.2 Maximum differential group delay

Differential group delay (DGD) is the time difference between the fractions of a pulse that are transmitted in the two principal states of polarisation of an optical signal. More information on this topic can be found in ITU-T Rec. G.691.

In this Recommendation, the maximum differential group delay is defined to be the value of DGD that the system must tolerate with a maximum sensitivity degradation of 1 dB.

6.3.4 Reflections

Reflections are caused by refractive index discontinuities along the optical path. If not controlled, they can degrade system performance through their disturbing effect on the operation of the optical source or amplifier, or through multiple reflections which lead to interferometric noise at the receiver. In this Recommendation, reflections from the optical path are controlled by specifying the:

– minimum Optical Return Loss (ORL) of the cable plant at point MPI-S, including any connectors; and
– maximum discrete reflectance between points MPI-S and MPI-R.

Reflectance denotes the reflection from any single discrete reflection point, whereas the return loss is the total returned power from the entire fibre including both discrete reflections and distributed backscattering such as Rayleigh scattering.

Measurement methods for reflections are described in Appendix II/G.957. For the purpose of reflectance and return loss measurements, points MPI-S and MPI-R are assumed to coincide with the endface of each connector plug. It is recognized that this does not include the actual reflection performance of the respective connectors in the operational system. These reflections are assumed to have the nominal value of reflection for the specific type of connectors used.

The maximum number of connectors or other discrete reflection points which may be included in the optical path (e.g. for distribution frames, or WDM components) must be such as to allow the specified overall optical return loss to be achieved. If this cannot be done using connectors meeting the maximum discrete reflections cited in Tables 3 and 4, then connectors having better reflection performance must be employed. Alternatively, the number of connectors must be reduced. It may also be necessary to limit the number of connectors, or to use connectors having improved reflectance performance in order to avoid unacceptable impairments due to multiple reflections.

In Tables 3 and 4 the value of –27 dB maximum discrete reflectance between points MPI-S and MPI-R is intended to minimise the effects of multiple reflections (e.g. interferometric noise). The value for maximum receiver reflectance is chosen to ensure acceptable penalties due to multiple reflections for all likely system configurations involving multiple connectors, etc. Systems employing fewer or higher performance connectors produce fewer multiple reflections and consequently are able to tolerate receivers exhibiting higher reflectance.

6.4 Receiver

6.4.1 Sensitivity

Receiver sensitivity is defined as the minimum acceptable value of mean received power at point MPI-R to achieve a 1×10^{-12} BER. It takes into account power penalties caused by use of a transmitter under standard operating conditions with worst-case values of transmitter eye mask, extinction ratio, optical return loss at point MPI-S, receiver connector degradations and measurement tolerances. The definition of receiver sensitivity under worst-case conditions is further discussed in Annex A/G.691.

The receiver sensitivity does not include power penalties associated with the path, such as dispersion, jitter, crosstalk or reflections. These effects are specified separately in the allocation of maximum optical path penalty.

The receiver sensitivities specified in Tables 3 and 4 are worst-case, end-of-life values. Start of life sensitivities must be adequate to account for receiver ageing and environmental conditions.

6.4.2 Overload

Receiver overload is the maximum acceptable value of the received average power at point MPI-R for a 1×10^{-12} BER.

6.4.3 Path penalty

The path penalty is the apparent reduction of receiver sensitivity due to distortion of the signal waveform during its transmission over the path. It is manifested as a shift of the system's BER-curves towards higher input power levels. This corresponds to a positive path penalty. Negative path penalties may exist under some circumstances, but should be small. (A negative path penalty indicates that a less than perfect transmitter eye has been partially improved by the path dependent distortions.) Ideally, the BER-curves should only be translated, but shape variations are not uncommon, and may indicate the emergence of BER-floors. Since the path penalty is a change in the receiver's sensitivity, it is measured at a BER-level of 10^{-12}.

A maximum path penalty of 1 dB for low-dispersion systems is allowed. The path penalties are not made proportional to the target distances to avoid operating systems with high penalties.

The average value of the random dispersion penalties due to PMD is included in the allowed path penalty. In this respect, the transmitter/receiver combination is required to tolerate an actual DGD of 0.3 bit period with a maximum sensitivity degradation of 1 dB (with 50% of optical power in each principal state of polarisation). For a well designed receiver, this corresponds to a penalty of 0.1-0.2 dB for a DGD of 0.1 bit period. The actual DGD that may be encountered in operation is a randomly varying fibre/cable property, and cannot be specified in this Recommendation. This subject is further discussed in Appendix I/G.691.

Any additional sensitivity degradation due to optical crosstalk (e.g. caused by non-ideal switching) is assumed to be small enough to be included within the path penalty value. Cases where this is not true are for further study. Optical crosstalk penalty is further discussed in Appendix I.

7 Optical parameter values

Optical parameter values for applications shown in Tables 1 and 2 are given in Tables 3 and 4. Systems which comply with these values should not require forward error correction in order to satisfy BER objectives. Tables 3 and 4 include columns in which more than one application code is shown in the heading. Where the row entries in these columns contain a single value, it applies to all of the application codes. Where the row contains multiple entries, the values apply to the application codes in the same order as they appear in the column heading.

Table 3/G.693 – Optical interface parameters specified for applications with 0.6 km target distance

Application code	Unit	VSR600-2R1	VSR600-2M1	VSR600-2M2 VSR600-2M3 VSR600-2M5
Target distance	m	600	600	600
Bit rate/line coding of optical signals	–	NRZ 10G	NRZ 10G	NRZ 10G
Fibre Type	–	G.652	G.652	G.652 G.653 G.655
Transmitter at reference point MPI-S				
Source type		MLM	MLM	SLM
Operating wavelength range	nm	1260-1360	1260-1360	1530-1565
Maximum mean output power	dBm	–1	+5	+2
Minimum mean output power	dBm	–6	+2	–1
Spectral characteristics:				
– maximum RMS width (σ)	nm	3	3	NA
– maximum –20 dB width	nm	NA	NA	ffs
– minimum SMSR	dB	NA	NA	30
Minimum EX	dB	6	6	8.2
Main optical path, MPI-S to MPI-R				
Maximum attenuation	dB	4	12	12
Minimum attenuation	dB	0	6[a)]	3[a)]
Maximum chromatic dispersion[b)]	ps/nm	3.8	3.8	12 for G.652[c)] 2 for G.653 6 for G.655
Maximum DGD	ps	30	30	30
Min ORL of cable plant at MPI-S, including any connectors	dB	14	14	14
Maximum discrete reflectance between MPI-S and MPI-R	dB	–27	–27	–27
Polarization dependent loss	dB	ffs	ffs	ffs
Receiver at reference point MPI-R				
Minimum sensitivity (BER of $1*10^{-12}$)	dBm	–11	–11	–14
Minimum overload	dBm	–1	–1	–1
Maximum optical path penalty	dB	1	1	1
Maximum reflectance of receiver, measured at MPI-R	dB	–14	–14	–14

a) This value of minimum attenuation is highly undesirable. A value of 0 dB is desired and should be sought as technology matures.

b) In the case that passive optical devices in the main optical path introduce additional chromatic dispersion, the achievable link distance may be reduced. Alternatively an application with a higher chromatic dispersion tolerance may be used to overcome this restriction.

c) This application can also be used on G.653 and G.655 fibre.

Table 4/G.693 – Optical interface parameters specified for applications with 2 km target distance

Application code	Unit	VSR2000-2R1	VSR2000-2L2 VSR2000-2L3 VSR2000-2L5	VSR2000-3R1	VSR2000-3R2 VSR2000-3R3 VSR2000-3R5	VSR2000-3M1	VSR2000-3M2 VSR2000-3M3 VSR2000-3M5	VSR2000-3H2 VSR2000-3H3 VSR2000-3H5
Target distance	km	2	2	2	2	2	2	2
Bit rate/line coding of optical signals	–	NRZ 10G	NRZ 10G	NRZ 40G	NRZ 40G	NRZ 40G	NRZ 40G	NRZ 40G
Fibre Type	–	G.652	G.652 G.653 G.655	G.652	G.652 G.653 G.655	G.652	G.652 G.653 G.655	G.652 G.653 G.655
Transmitter at reference point MPI-S								
Source type		SLM	SLM	SLM	SLM	SLM	SLM	SLM
Operating wavelength range	nm	1290-1330	1530-1565	1290-1330	1530-1565	1290-1330	1530-1565	1530-1565
Maximum mean output power	dBm	–1	–1	+3	+3	+10	+3	+3
Minimum mean output power	dBm	–6	–5	0	0	+8	0	0
Spectral characteristics:								
– maximum RMS width (σ)	nm	NA	NA	NA	NA	NA	NA	NA
– maximum –20 dB width	nm	1	ffs	ffs	ffs	ffs	ffs	ffs
– minimum SMSR	dB	30	30	35	35	35	35	35
Minimum EX	dB	6	8.2	10	8.2	10	7	7
Main optical path, MPI-S to MPI-R								
Maximum attenuation	dB	4	6	4	4	12	12	16
Minimum attenuation	dB	0	0	0	0	8[a)]	3[a)]	3
Maximum chromatic dispersion[b)]	ps/nm	6.6	40	6.6	40 for G.652[c)] 6.6 for G.653 20 for G.655	6.6	40 for G.652[c)] 6.6 for G.653 20 for G.655	40 for G.652[c)] 6.6 for G.653 20 for G.655
Maximum DGD	ps	30	30	7.5	7.5	7.5	7.5	7.5
Min ORL of cable plant at MPI-S, including any connectors	dB	14	24	24	24	24	24	24
Maximum discrete reflectance between MPI-S and MPI-R	dB	–27	–27	–27	–27	–27	–27	–27
Polarization dependent loss	dB	ffs	ffs	ffs	ffs	ffs	ffs	ffs

Table 4/G.693 – Optical interface parameters specified for applications with 2 km target distance ***(concluded)***

Application code	Unit	VSR2000-2R1	VSR2000-2L2 VSR2000-2L3 VSR2000-2L5	VSR2000-3R1	VSR2000-3R2 VSR2000-3R3 VSR2000-3R5	VSR2000-3M1	VSR2000-3M2 VSR2000-3M3 VSR2000-3M5	VSR2000-3H2 VSR2000-3H3 VSR2000-3H5
Receiver at reference point MPI-R								
Minimum sensitivity (BER of $1*10^{-12}$)	dBm	–11	–13	–5	–5	–5	–13	–17
Minimum overload	dBm	–1	–1	+3	+3	+2	0	0
Maximum optical path penalty	dB	1	2	1[d)]	1[d)]	1[d)]	1[d)]	1[d)]
Maximum reflectance of receiver, measured at MPI-R	dB	–14	–27	–27	–27	–27	–27	–27

a) This value of minimum attenuation is highly undesirable. A value of 0 dB is desired and should be sought as technology matures.

b) In the case that passive optical devices in the main optical path introduce additional chromatic dispersion, the achievable link distance may be reduced. Alternatively an application with a higher chromatic dispersion tolerance may be used to overcome this restriction.

c) This application can also be used on G.653 and G.655 fibre.

d) The method used to verify this penalty is ffs.

8 Optical engineering approach

For a worst-case design approach, the relationships among Maximum/Minimum mean output power, Maximum/Minimum attenuation, Minimum overload, Minimum sensitivity and Maximum optical path penalty are shown in Figure 3/G.957.

Appendix I

Optical crosstalk impact

Some of the applications in this Recommendation are intended to support the inclusion of a passive photonic cross-connect in the main optical path as depicted in Figure I.1. Photonic cross-connects may introduce non-negligible optical crosstalk due to non-ideal switching.

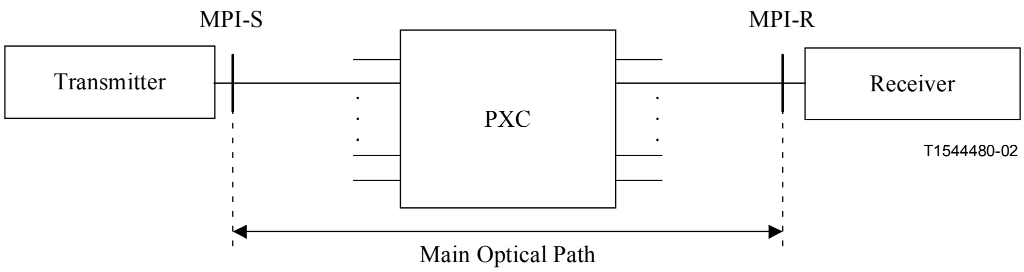

Figure I.1/G.693 – Optical link example showing use of a passive photonic cross-connect between MPI-S and MPI-R

Optical Crosstalk is the ratio of the total disturbing power, under all specified conditions, to the power in the desired signal, at the MPI-R reference point in Figure I.1, within the optical bandwidth of the optical receiver, expressed in dB.

Optical system performance may be affected by the level of optical crosstalk in the signal arriving at the receiver. Excessive optical crosstalk at the receiver will cause the performance of the system to deteriorate by an amount defined to be the crosstalk penalty.

Further study is needed to quantify the allowable optical crosstalk penalty.

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