

Recommendation

ITU-T G.654 (08/2024)

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

Transmission media and optical systems characteristics –
Optical fibre cables

Characteristics of a cut-off shifted single-mode optical fibre and cable

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Recommendation ITU-T G.654

Characteristics of a cut-off shifted single-mode optical fibre and cable

Summary

Recommendation ITU-T G.654 describes the geometrical, mechanical and transmission attributes of a single-mode optical fibre and cable which has the zero-dispersion wavelength around 1300 nm wavelength, and which is loss-minimized and cut-off wavelength shifted at around the 1550 nm wavelength region. This is the latest revision of this Recommendation that was first created in 1988.

History *

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Cut-off shifted single-mode optical fibre and cable, large mode field diameter fibre, long haul transmission, optical fibre and cable.

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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.

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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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Change log

History of this Recommendation since it was first approved in 1988.

- 1988 Recommendation ITU-T G.654, *Characteristics of a 1550 nm wavelength loss-minimized single-mode optical fibre cable*, was created.
- 2000 The fourth version of Recommendation ITU-T G.654 changed the Recommendation structure, in accordance with other fibre Recommendations such as ITU-T G.652, G.653 and G.655.
- 2002 The fifth version of Recommendation ITU-T G.654 added a new fibre category with changed fibre attributes of mode field diameter and chromatic dispersion coefficient as G.654.B. According to the agreement on spectral bands, description of L-band upper limit was changed from 16xx nm to 1625 nm. The terms of base subcategory and subcategory were revised to base category and category, respectively.
- 2004 The sixth version of Recommendation ITU-T G.654 reduced PMD_Q limit from 0.5 ps/√km to 0.2 ps/√km in G.654.B and added a new category G.654.C which has the reduced PMD_Q limit. Tolerance of mode field diameter in G.654.B was also reduced to ±0.7 μm. For the macrobending test, mandrel radius is reduced to 30 mm.
- 2006 The seventh version of Recommendation ITU-T G.654 changed the notation of PMD in order to make it consistent with that of Recommendation ITU-T G.652.
- 2010 The eighth version of Recommendation ITU-T G.654 removed the jumper cut-off wavelength definition and added notes allowing higher maximum cabled attenuation for short cables such as jumper cables.
- 2012 The ninth version of Recommendation ITU-T G.654 introduced category G.654.D in order to improve the optical signal to noise ratio (OSNR) characteristics, e.g., which can be applied to higher bit-rate submarine systems.
- 2016 The tenth version of Recommendation ITU-T G.654 introduced category G.654.E in order to significantly improve the optical signal to noise ratio (OSNR) characteristics to support 100 Gbit/s and beyond 100 Gbit/s digital coherent transmission systems in terrestrial deployments.
- 2020 The eleventh version of Recommendation ITU-T G.654 changed the attenuation coefficient of ITU-T G.654.E to specify a wavelength dependency for estimating optical system design. A note was also added for cable cut-off wavelength when ITU-T G.654.E fibre is used at central frequencies for applications specified in Recommendation ITU-T G.698.2.
- 2024 The twelfth version of Recommendation ITU-T G.654 removed fibre cut-off wavelength recommendation and a note regarding cut-off wavelength in WDM applications. Meanwhile, a new note for cut-off wavelength property under a unique deployment condition are added. In a note for cable cut-off wavelength when G.654.E fibre is used at central frequencies for applications specified in Recommendation ITU-T G.698.2, the upper limit was changed from 1527.8 nm to 1527 nm considering the measurement accuracy. This revision is intended to maintain the continuing commercial success of this fibre in the evolving world of high-performance optical transmission systems.

Recommendation ITU-T G.654

Characteristics of a cut-off shifted single-mode optical fibre and cable

1 Scope

This Recommendation describes a single-mode optical fibre and cable, which has the zero-dispersion wavelength around 1300 nm, which is loss-minimized and cut-off shifted at a wavelength around 1550 nm and which is optimized for use in the 1530-1625 nm region.

This very low loss cut-off shifted fibre (CSF) can be used for long-distance digital transmission applications, such as long-haul terrestrial line systems and submarine cable systems using optical amplifiers. The geometrical, optical transmission (attenuation, cut-off wavelength, chromatic dispersion and polarization mode dispersion (PMD), etc.), and mechanical characteristics of this CSF are described.

Some provisions are made to support transmission at higher wavelengths up to 1625 nm. The geometrical, optical transmission, and mechanical parameters are described in three categories of attributes:

- fibre attributes that are retained throughout cabling and installation;
- cable attributes that are recommended for cables as they are delivered;
- link attributes that are characteristics of concatenated cables, describing estimation methods of system interface parameters based on measurements, modelling or other considerations. Information for link attributes and system design are given in Appendix I.

This Recommendation, and the different performance categories found in Tables 1 to 5 in clause 8, are intended to support the following related-system Recommendations:

Category	Recommendations
Characteristics of optical systems	[b-ITU-T G.696.1]
Digital line systems	[b-ITU-T G.957]
Optical fibre submarine cable systems	[b-ITU-T G.973], [b-ITU-T G.973.1], [b-ITU-T G.973.2], [b-ITU-T G.977.1]

The meaning of the terms used in this Recommendation, and the guidelines to be followed in the measurements to verify the various characteristics, are given in [ITU-T G.650.1] and [ITU-T G.650.2]. The characteristics of this fibre, including the definitions of the relevant parameters, their test methods and relevant values, will be refined as studies and experience progress.

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.650.1] Recommendation ITU-T G.650.1 (2024), *Definitions and test methods for linear, deterministic attributes of single-mode fibre and cable*.

[ITU-T G.650.2] Recommendation ITU-T G.650.2 (2015), *Definitions and test methods for statistical and non-linear related attributes of single-mode fibre and cable*.

- [ITU-T G.652] Recommendation ITU-T G.652 (2024), *Characteristics of a single-mode optical fibre and cable*.
- [ISO 80000-1] ISO 80000-1:2022, *Quantities and units – Part 1: General*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the terms given in [ITU-T G.650.1] and [ITU-T G.650.2].

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CSF	Cut-off Shifted Fibre
DGD	Differential Group Delay
DWDM	Dense Wavelength Division Multiplexing
MFD	Mode Field Diameter
OSNR	Optical Signal to Noise Ratio
PMD	Polarization Mode Dispersion
PMD _Q	Statistical parameter for link PMD
TBD	To Be Determined
WDM	Wavelength Division Multiplexing

5 Conventions

Values shall be rounded to the number of digits in the recommended values listed in Tables 1 to 5 before conformance is evaluated. The conventional rule of "rounding half away from zero" is used, which is described in rule B of Annex B of [ISO 80000-1]. Only the first digit beyond the number of significant digits is used in determining the rounding.

6 Fibre attributes

Only those characteristics of the fibre that provide a minimum essential design framework for fibre manufacturers are recommended in this clause. Ranges or limits on values are presented in Tables 1 to 5 in clause 8. Of these, cable manufacture or installation may significantly affect the cabled fibre cut-off wavelength and polarization mode dispersion (PMD). Otherwise, the recommended characteristics will apply equally to individual fibres, fibres incorporated into a cable wound on a drum and fibres in an installed cable.

6.1 Mode field diameter

Both a nominal value and tolerance about that nominal value of mode field diameter (MFD) shall be specified at 1550 nm. The nominal values of the MFD that are specified shall be within the ranges found in clause 8. The specified tolerance of the MFD shall not exceed the value in clause 8. The deviation from nominal shall not exceed the specified tolerance.