



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.955

(11/96)

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

Digital transmission systems – Digital sections and digital
line system – Digital line systems

**Digital line systems based on the 1544 kbit/s
and the 2048 kbit/s hierarchy on optical fibre
cables**

ITU-T Recommendation G.955

(Previously CCITT Recommendation)

ITU-T G-SERIES RECOMMENDATIONS
TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
INTERNATIONAL ANALOGUE CARRIER SYSTEM	
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA CHARACTERISTICS	G.600–G.699
DIGITAL TRANSMISSION SYSTEMS	
TERMINAL EQUIPMENTS	G.700–G.799
General	G.700–G.709
Coding of analogue signals by pulse code modulation	G.710–G.719
Coding of analogue signals by methods other than PCM	G.720–G.729
Principal characteristics of primary multiplex equipment	G.730–G.739
Principal characteristics of second order multiplex equipment	G.740–G.749
Principal characteristics of higher order multiplex equipment	G.750–G.759
Principal characteristics of transcoder and digital multiplication equipment	G.760–G.769
Operations, administration and maintenance features of transmission equipment	G.770–G.779
Principal characteristics of multiplexing equipment for the synchronous digital hierarchy	G.780–G.789
Other terminal equipment	G.790–G.799
DIGITAL NETWORKS	G.800–G.899
General aspects	G.800–G.809
Design objectives for digital networks	G.810–G.819
Quality and availability targets	G.820–G.829
Network capabilities and functions	G.830–G.839
SDH network characteristics	G.840–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
General	G.900–G.909
Parameters for optical fibre cable systems	G.910–G.919
Digital sections at hierarchical bit rates based on a bit rate of 2048 kbit/s	G.920–G.929
Digital line transmission systems on cable at non-hierarchical bit rates	G.930–G.939
Digital line systems provided by FDM transmission bearers	G.940–G.949
Digital line systems	G.950–G.959
Digital section and digital transmission systems for customer access to ISDN	G.960–G.969
Optical fibre submarine cable systems	G.970–G.979
Optical line systems for local and access networks	G.980–G.999

For further details, please refer to ITU-T List of Recommendations.

ITU-T RECOMMENDATION G.955

DIGITAL LINE SYSTEMS BASED ON THE 1544 kbit/s AND THE 2048 kbit/s HIERARCHY ON OPTICAL FIBRE CABLES

Summary

This Recommendation provides specifications for the transmission of optical signals based on both the 1544 kbit/s and 2048 kbit/s hierarchies.

Source

ITU-T Recommendation G.955 was revised by ITU-T Study Group 15 (1993-1996) and was approved under the WTSC Resolution No. 1 procedure on the 8th of November 1996.

...

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The 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 Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 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.

INTELLECTUAL PROPERTY RIGHTS

The ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. The ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, the ITU had/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.

© ITU 1997

All rights reserved. No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the ITU.

CONTENTS

	Page
1 Scope	1
2 References	1
3 Terms and definitions	2
4 Abbreviations	2
5 Type of transmission medium	3
6 System margin	3
7 System specifications	4
7.1 Regenerator section lengths	4
7.2 Error performance	5
7.3 Receiver dynamic range	9
7.4 Optical source	9
7.5 Operating wavelength range	9
7.6 Optical path allowances for multimode fibre systems	10
7.7 Optical path allowances for single-mode fibre systems	10
7.8 Equipment margin (M_e)	10
7.9 Wavelength division multiplexing	10
8 Power feeding	11
9 Systems for short haul applications	11
10 Working conditions	11
11 Overall design features	11
12 Maintenance strategy	12
12.1 Type of supervision and fault location	12
12.2 Fault conditions and consequent actions	12
13 Safety considerations	12
Appendix I – Calculation of regenerator section length	13
I.1 Approaches	13
I.1.1 Worst-case approach	13
I.1.2 Statistical approach	14
I.1.3 Semi-statistical approach	15
I.2 Statistical data form	16
I.3 Examples	16
I.4 An example of a statistical optical power budget	16



Recommendation G.955**DIGITAL LINE SYSTEMS BASED ON THE 1544 kbit/s AND THE
2048 kbit/s HIERARCHY ON OPTICAL FIBRE CABLES¹***(revised in 1996)***1 Scope**

This Recommendation covers digital line systems for the transmission of signals based on both the 1544 kbit/s and the 2048 kbit/s hierarchy on optical fibre cables and includes systems conveying the following bit rates:

2 048 kbit/s	1 544 kbit/s
8 448 kbit/s	3 152 kbit/s
34 368 kbit/s	6 312 kbit/s
139 264 kbit/s	32 064 kbit/s
4 × 139 264 kbit/s	44 736 kbit/s
	$n \times 44 736$ kbit/s
	97 728 kbit/s
	4 × 97 728 kbit/s

The requirements for overall performance and interfaces of the corresponding digital sections are given in G.900-Series Recommendations.

The aim of this Recommendation is to achieve longitudinal compatibility on elementary cable sections of different digital line systems, i.e. the possibility of installing digital line systems, produced by different manufacturers, on the same optical fibre cable.

For the purpose of this Recommendation, optical fibre digital line systems can be represented as in Figure 1. The system may have no intermediate regenerators as in diagram a) of Figure 1, one intermediate regenerator as in diagram b) of Figure 1 or a larger number depending on the system design and route length.

This Recommendation covers requirements for equipment intended to meet the relevant performance objectives of Recommendations G.821 and G.921 under all normally envisaged operating conditions. In any event, Recommendation G.821 remains the overriding performance objective of the network.

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; all 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.650 (1997), *Definition and test methods for the relevant parameters of single-mode fibres*.

¹ Recommendation G.955 totally replaces Recommendations G.955 and G.956 as contained in the *Blue Book*.

- ITU-T Recommendation G.651 (1993), *Characteristics of a 50/125 μ m multimode graded index optical fibre cable.*
- ITU-T Recommendation G.652 (1997), *Characteristics of a single-mode optical fibre cable.*
- ITU-T Recommendation G.653 (1997), *Characteristics of a dispersion-shifted single-mode optical fibre cable.*
- ITU-T Recommendation G.654 (1997), *Characteristics of a cut-off shifted single-mode optical fibre cable.*
- CCITT Recommendation G.703 (1991), *Physical/electrical characteristics of hierarchical digital interfaces.*
- ITU-T Recommendation G.821 (1996), *Error performance of an international digital connection operating at a bit rate below the primary rate and forming part of an integrated services digital network.*
- CCITT Recommendation G.921 (1988), *Digital sections based on the 2048 kbit/s hierarchy.*
- CCITT Recommendation G.950 (1988), *General considerations on digital line systems.*
- ITU-T Recommendation G.957 (1995), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy.*
- IEC 479, *Effects of current on human beings and livestock, Part 1 (1994) – General aspects; Part 2 (1987) – Special aspects.*
- IEC 825 (1993), *Safety of laser products, Part 1 – Equipment classification, requirements and user's guide; Part 2 – Safety of optical fibre communication systems.*

3 Terms and definitions

This Recommendation defines the following terms:

- 3.1 longitudinal compatibility:** The capability of installing digital line systems, produced by different manufacturers on the same optical fibre cable.
- 3.2 cable margin:** See 6.1.
- 3.3 equipment margin:** See 6.2.

4 Abbreviations

This Recommendation uses the following abbreviations:

BER	Bit Error Ratio
C	Connector
FWHM	Full-Width Half-Maximum
ISI	Inter-Symbol Interference
LED	Light-Emitting Diode
M_c	Cable Margin
M_e	Equipment Margin
MLM	Multi-Longitudinal Mode
N/A	Not Applicable
OFA	Optical Fibre Amplifier

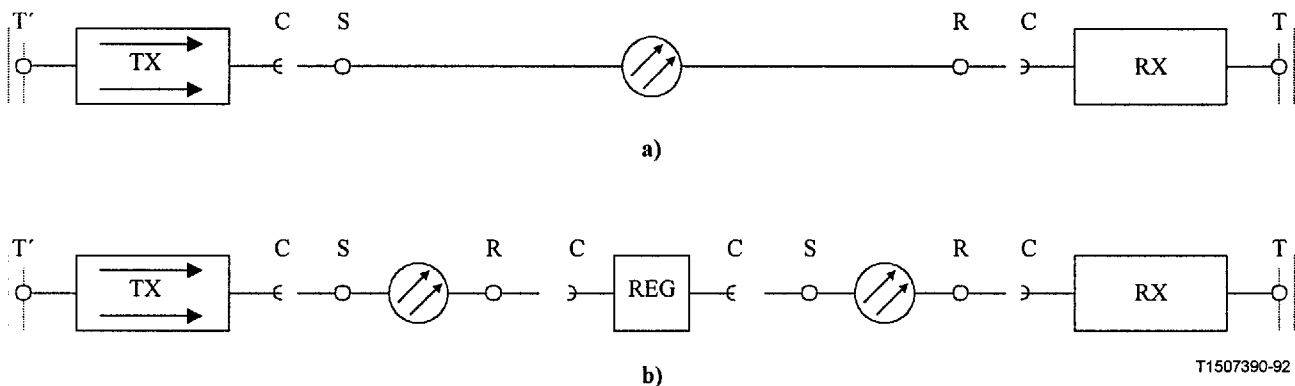
PDF	Probability Distribution Function
REG	Regenerator
Rx	Receiver
SLM	Single Longitudinal Mode
Tx	Transmitter

5 Type of transmission medium

Multimode optical fibres conforming to Recommendation G.651 or single-mode optical fibres conforming to Recommendations G.652, G.653 and G.654 are considered suitable for these systems. Operation may be in the region of either 850 nm, 1310 nm or 1550 nm or some other wavelength depending on the fibre and system type employed. The attenuation considered the most appropriate for operation at the various bit rates and wavelengths will be chosen by the Administrations in relation to the characteristics of the link to be realized and in accordance with this Recommendation. Similarly, splice losses, connector losses and the cable margin must be chosen together with the attenuation of the optical fibre in order to achieve the overall attenuation specified in clause 7.

6 System margin

For the purpose of this Recommendation, the total system margin [see diagram a) of Figure 1], or regenerator section margin [see diagram b) of Figure 1], is subdivided into two main contributions. The disposition of these margins is shown in Figure 2.



T, T' Equipment interface in accordance with Recommendation G.703.
S Point on the optical fibre just after the Transmitter (TX) or the Regenerator (REG) optical Connector (C).
R Point on the optical fibre just before the Receiver (RX) or the Regenerator (REG) optical Connector (C).

NOTE – Additional connectors at a distribution frame (if used) are considered to be part of fibre link and to be located between points S and R.

Figure 1/G.955