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SERIES O: SPECIFICATIONS OF MEASURING
EQUIPMENT

General

**Scope and application of measurement
equipment specifications covered in the
O-series Recommendations**

ITU-T Recommendation O.1

(Formerly CCITT Recommendation)

ITU-T O-SERIES RECOMMENDATIONS
SPECIFICATIONS OF MEASURING EQUIPMENT

General	O.1–O.9
Maintenance access	O.10–O.19
Automatic and semi-automatic measuring systems	O.20–O.39
Equipment for the measurement of analogue parameters	O.40–O.129
Equipment for the measurement of digital and analogue/digital parameters	O.130–O.199

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

ITU-T Recommendation O.1

Scope and application of measurement equipment specifications covered in the O-series Recommendations

Summary

This ITU-T Recommendation gives a summary of the content of all O-series Recommendations. It lists the titles and contains information on scope and application of the Recommendations.

In addition, an alphabetical list of measurement terms covered by O-series Recommendations helps the reader to select the right Recommendation for his/her application.

Appendix I contains information about a crosstalk test device for carrier transmission systems.

Source

ITU-T Recommendation O.1 was revised by ITU-T Study Group 4 (1997-2000) and approved under the WTSC Resolution 1 procedure on 4 February 2000.

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 Conference (WTSC), 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 WTSC 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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CONTENTS

	Page
1	Scope..... 1
2	References..... 1
3	Abbreviations..... 2
4	How to use this Recommendation 3
5	Content of the O-series Recommendations..... 3
5.1	General Recommendations 4
5.1.1	Recommendation O.3 – Climatic conditions and relevant tests for measuring equipment..... 4
5.1.2	Recommendation O.6 – 1020 Hz reference test frequency 4
5.1.3	Recommendation O.9 – Measuring arrangements to assess the degree of unbalance about Earth..... 4
5.2	Maintenance access..... 4
5.2.1	Recommendation O.11 – Maintenance access lines..... 4
5.3	Automatic and semi-automatic measuring systems 5
5.3.1	Recommendation O.22 – CCITT Automatic Transmission Measuring and signalling testing Equipment ATME No. 2 5
5.3.2	Recommendation O.27 – In-Station Echo canceller Test equipment..... 5
5.3.3	Recommendation O.33 – Automatic equipment for rapidly measuring stereophonic pairs and monophonic sound-programme circuits, links and connections 5
5.4	Equipment for the measurement of analogue parameters 5
5.4.1	Recommendation O.41 – Psophometer for use on telephone-type circuits... 5
5.4.2	Recommendation O.42 – Equipment to measure non-linear distortion using the 4-tone intermodulation method..... 6
5.4.3	Recommendation O.61 – Simple equipment to measure interruptions on telephone-type circuits..... 6
5.4.4	Recommendation O.62 – Sophisticated equipment to measure interruptions on telephone-type circuits 6
5.4.5	Recommendation O.71 – Impulsive noise measuring equipment for telephone-type circuits..... 6
5.4.6	Recommendation O.72 – Characteristics of an impulsive noise measuring instrument for wideband data transmissions..... 6
5.4.7	Recommendation O.81 – Group-delay measuring equipment for telephone-type circuits..... 6
5.4.8	Recommendation O.82 – Group-delay measuring equipment for the range 5 to 600 kHz..... 7
5.4.9	Recommendation O.91 – Phase jitter measuring equipment for telephone-type circuits..... 7
5.4.10	Recommendation O.95 – Phase and amplitude hit counters for telephone-type circuits..... 8

5.4.11	Recommendation O.111 – Frequency shift measuring equipment for use on carrier channels.....	8
5.5	Equipment for the measurement of analogue/digital and digital parameters.....	8
5.5.1	Recommendation O.131 – Quantizing distortion measuring equipment using a pseudo-random noise test signal.....	8
5.5.2	Recommendation O.132 – Quantizing distortion measuring equipment using a sinusoidal test signal.....	9
5.5.3	Recommendation O.133 – Equipment for measuring the performance of PCM encoders and decoders	9
5.5.4	Recommendation O.150 – General requirements for instrumentation for performance measurements on digital transmission equipment	10
5.5.5	Recommendation O.151 – Error performance measuring equipment for digital systems at the primary bit rate and above	10
5.5.6	Recommendation O.152 – Error performance measuring equipment for bit rates of 64 kbit/s and $N \times 64$ kbit/s.....	10
5.5.7	Recommendation O.153 – Basic parameters for the measurement of error performance at bit rates below the primary rate.....	10
5.5.8	Recommendation O.161 – In-service code violation monitors for digital systems	10
5.5.9	Recommendation O.162 – Equipment to perform in-service monitoring on 2048, 8448, 34 368 and 139 264 kbit/s signals	10
5.5.10	Recommendation O.163 – Equipment to perform in-service monitoring on 1544 kbit/s signals	11
5.5.11	Recommendation O.171 – Timing jitter and wander measuring equipment for digital systems which are based on the Plesiochronous Digital Hierarchy (PDH).....	11
5.5.12	Recommendation O.172 – Jitter and wander measuring equipment for digital systems which are based on the Synchronous Digital Hierarchy (SDH).....	11
5.5.13	Recommendation O.181 – Equipment to assess error performance on STM-N interfaces	12
5.5.14	Recommendation O.191 – Equipment to measure the cell transfer performance of ATM connections.....	12
Annex A – Alphabetical list of measurement terms covered by O-Series Recommendations.....		13
Appendix I – Crosstalk test device for carrier transmission on coaxial systems		21
I.1	Introduction.....	21
I.2	Operation	21
I.3	Basic technical parameters of a device designed for transmission systems at frequencies less than 18 MHz.....	23
I.3.1	Basic characteristics.....	23
I.3.2	Several technical characteristics	23

Introduction

This Recommendation is intended to help maintenance personnel and other interested parties to select the test equipment specified by an O-series Recommendation which is applicable to a specific measurement task.

For this reason, this Recommendation lists the titles of all O-series Recommendations and informs about their scope and application. An alphabetical list of measurement terms covered by the O-series Recommendations is given in Annex A.

This Recommendation does not contain any test equipment specification.

Background

Within the ITU Standardization Sector, Study Group 4 is responsible for Network Maintenance. One of its tasks is defining measuring equipment required to assess network quality. Different kinds of measuring equipment Recommendations have to be considered, namely those covering:

- a) conformance tests for telecommunications equipment; and
- b) operational matters, e.g. procedures for bringing circuits into service and routine performance checks.

The kinds of tests for checking compliance with these two categories of Recommendations are essentially different, and this often leads to a different choice of test equipment.

Category a) tests will normally be more comprehensive. Their purpose (often based upon measurements of sample or prototype equipment) is to certify compliance with design objectives and they may therefore be a prerequisite to equipment being accepted for installation in a network. Such tests are unlikely to be employed routinely.

Category b) tests, however, are used systematically and repetitively and their widespread application may necessitate additional considerations, in particular the need for:

- 1) conformity of results when tests may be performed using test equipment supplied by several manufacturers; and
- 2) a common measurement technique to ensure compatibility when a test requires measurement equipment at both ends of a device under test.

It is primarily for these circumstances that ITU-T issues the O-series Recommendations.

The above remarks apply equally to analogue and digital techniques.

ITU-T Recommendation O.1

Scope and application of measurement equipment specifications covered in the O-series Recommendations

1 Scope

This ITU-T Recommendation is intended to help maintenance personnel and other interested parties to select the test equipment specified by an O-series Recommendation which is applicable to a specific measurement task.

For this reason, this Recommendation lists the titles of all O-series Recommendations and informs about their scope and application. An alphabetical list of measurement terms covered by the O-series Recommendations is given in Annex A.

This Recommendation does not contain any test equipment specification.

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.

- [1] ITU-T Recommendation G.117 (1996), *Transmission aspects of unbalance about Earth.*
- [2] ITU-T Recommendation G.165 (1993), *Echo cancellers.*
- [3] ITU-T Recommendation G.712 (1996), *Transmission performance characteristics of pulse code modulation.*
- [4] ITU-T Recommendations Q.550-series, *Transmission characteristics.*
- [5] 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.*
- [6] ITU-T Recommendation G.826 (1999), *Error performance parameters and objectives for international, constant bit rate digital paths at or above the primary rate.*
- [7] ITU-T Recommendation M.2100 (1995), *Performance limits for bringing-into-service and maintenance of international PDH paths, sections and transmission systems.*
- [8] ITU-T Recommendation G.707 (1996), *Network node interface for the synchronous digital hierarchy (SDH).*
- [9] ITU-T Recommendation G.783 (1997), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks.*
- [10] ITU-T Recommendation G.784 (1999), *Synchronous digital hierarchy (SDH) management.*
- [11] ITU-T Recommendation M.2101 (2000), *Performance limits and objectives for bringing-into-service and maintenance of international SDH paths and multiple sections.*
- [12] ITU-T Recommendation I.356 (2000), *B-ISDN ATM layer cell transfer performance.*
- [13] ITU-T Recommendation I.357 (1996), *B-ISDN semi-permanent connection availability.*

- [14] ITU-T Recommendation I.361 (1999), *B-ISDN ATM layer specification.*
- [15] ITU-T Recommendation I.610 (1999), *B-ISDN operation and maintenance principles and functions.*
- [16] ITU-T Recommendation G.823 (2000), *The control of jitter and wander within digital networks which are based on the 2048 kbit/s hierarchy.*
- [17] ITU-T Recommendation G.824 (2000), *The control of jitter and wander within digital networks which are based on the 1544 kbit/s hierarchy.*
- [18] ITU-T Recommendation G.825 (2000), *The control of jitter and wander within digital networks which are based on the synchronous digital hierarchy (SDH).*
- [19] CCITT Recommendation G.793 (1988), *Characteristics of 60-channel transmultiplexing equipments.*
- [20] CCITT Recommendation G.794 (1988), *Characteristics of 24-channel transmultiplexing equipments.*
- [21] ITU-T Recommendation G.704 (1998), *Synchronous frame structures used at 1544, 6312, 2048, 8448 and 44 736 kbit/s hierarchical levels.*
- [22] CCITT Recommendation G.751 (1988), *Digital multiplex equipments operating at the third order bit rate of 34 368 kbit/s and the fourth order bit rate of 139 264 kbit/s and using positive justification.*

3 Abbreviations

This Recommendation uses the following abbreviations:

A-A	Analogue to Analogue
A-D	Analogue to Digital
AIS	Alarm Indication Signal
AMI	Alternate Mark Inversion
ATM	Asynchronous Transfer Mode
ATME	Automatic Transmission Measuring and signalling testing Equipment
AU-AIS	Administrative Unit Alarm Indication Signal
AU-LOP	Administrative Unit Loss Of Pointer
CDV	Cell Delay Variation
CER	Cell Error Ratio
CLR	Cell Loss Ratio
CMR	Cell Misinsertion Rate
CMR	Common Mode Rejection
CRC	Cyclic Redundancy Check
CTD	Cell Transfer Delay
D-A	Digital to Analogue
D-D	Digital to Digital
HDB 3	High Density Bipolar with 4-zero suppression
HP-RDI	Higher-order Path Remote Defect Indication

HP-REI	Higher-order Path Remote Error Indication
HP-TIM	Higher-order Path Trace Identifier Mismatch
ILIL	Input Longitudinal Interference Loss
ISET	In-Station Echo canceller Test equipment
LCL	Longitudinal Conversion Loss
LCTL	Longitudinal Conversion Transfer Loss
LOF	Loss Of Frame alignment
LOS	Loss Of Signal
LP-RDI	Lower-order Path Remote Defect Indication
LP-REI	Lower-order Path Remote Error Indication
LP-TIM	Lower-order Path Trace Identifier Mismatch
MS-AIS	Multiplex Section Alarm Indication Signal
MS-RDI	Multiplex Section Remote Defect Indication
OOF	Out Of Frame alignment
OSB	Output Signal Balance
PDH	Plesiochronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy
TCL	Transverse Conversion Loss
TCTL	Transverse Conversion Transfer Loss
TU-AIS	Tributary Unit Alarm Indication Signal
TU-LOM	Tributary Unit Loss Of Multiframe alignment
TU-LOP	Tributary Unit Loss Of Pointer

4 How to use this Recommendation

Clause 5 lists the titles of all O-series Recommendations including a brief summary of the relevant specification. Titles and summaries are in most cases sufficiently descriptive to select the O-series Recommendation applicable to the measurement task the reader is interested in.

In addition, Annex A provides a comprehensive index of measurement related terms and abbreviations covered in O-series Recommendations. Where useful, index entries are given twice: Firstly under a summary keyword (e.g. PCM encoder/decoder, quantizing distortion) and secondly under the specific task (e.g. quantizing distortion). Using the index is the easiest way to find the relevant O-Recommendation.

5 Content of the O-series Recommendations

This clause is presented as an aid to selecting and applying measuring instrumentation specified in the O-series Recommendations. It gives an overview of the titles and the content of these Recommendations which can be categorized into five classes, namely:

- General Recommendations.
- Recommendations dealing with maintenance access lines.
- Automatic and semi-automatic measuring systems.

- Equipment for the measurement of analogue parameters.
- Equipment for the measurement of analogue/digital and digital parameters.

5.1 General Recommendations

5.1.1 Recommendation O.3 – Climatic conditions and relevant tests for measuring equipment

The Recommendations of the O-series specify measurement equipment for a wide range of applications. Reliable test equipment is an important prerequisite when maintaining telecommunication equipment and telecommunication networks. The reliability of measuring equipment can be affected by the environmental conditions to which the equipment is exposed to during its use.

Recommendation O.3 gives a range of climatic conditions for the indoor operation of measuring equipment specified in the O-series Recommendations. In addition, climatic conditions for transportation and storage of measuring equipment are defined.

In order to be able to prove that the requirements of Recommendation O.3 are fulfilled, test conditions simulating the various environmental parameters are specified.

5.1.2 Recommendation O.6 – 1020 Hz reference test frequency

The intent of Recommendation O.6 is to specify a single nominal reference frequency of 1020 Hz in order to provide guidance to manufacturers and network operators in the design and operation of equipment and systems. In addition to the nominal reference frequency, Recommendation O.6 defines a nominal reference level of -10 dBm₀.

Recommendation O.6 takes into account the specific difficulties of testing circuits routed over PCM systems.

5.1.3 Recommendation O.9 – Measuring arrangements to assess the degree of unbalance about Earth

Recommendation O.9 describes arrangements for measuring the following parameters:

- Longitudinal Conversion Loss (LCL);
- Transverse Conversion Loss (TCL);
- Longitudinal Conversion Transfer Loss (LCTL);
- Transverse Conversion Transfer Loss (TCTL);
- Input Longitudinal Interference Loss (ILIL);
- Common Mode Rejection (CMR);
- Output Signal Balance (OSB).

In practice, these are the seven most significant unbalance parameters. Limits, special considerations for test terminations and the measurement frequencies to be used are given.

Recommendation O.9 is based upon Recommendation G.117 [1] which contains additional information on unbalanced a measurements.

5.2 Maintenance access

5.2.1 Recommendation O.11 – Maintenance access lines

In order to more effectively carry out manual and automatic maintenance of international circuits in an automatic telephone network, Recommendation O.11 gives the basic specifications for maintenance access lines.

This includes requirements for access lines when testing echo cancellers (see Recommendation O.27) and when using the Automatic Transmission Measuring and signalling testing Equipment – ATME No. 2 (see Recommendation O.22).

5.3 Automatic and semi-automatic measuring systems

5.3.1 Recommendation O.22 – CCITT Automatic Transmission Measuring and signalling testing Equipment ATME No. 2

The Automatic Transmission Measuring and signalling testing Equipment (ATME No. 2) is intended to make transmission measurements, echo canceller tests and signalling system functional tests on all categories of international circuits terminating in exchanges with 4-wire switching.

Recommendation O.22 describes the:

- kinds of measurements and tests;
- equipment for making transmission measurements and processing the results;
- method of access;
- operating principles;
- signalling system testing and transmission measuring procedures;
- test to digital loopback lines.

5.3.2 Recommendation O.27 – In-Station Echo canceller Test equipment

The In-Station Echo canceller Test equipment (ISET) is intended to test type C and D echo cancellers including tone disablers as specified in Recommendation G.165 [2]. Two test modes, routine tests and diagnostic tests, are described.

5.3.3 Recommendation O.33 – Automatic equipment for rapidly measuring stereophonic pairs and monophonic sound-programme circuits, links and connections

The automatic measuring equipment for sound-programme circuits is capable of rapidly measuring all relevant parameters necessary for checking the quality of such circuits. These parameters are:

- attenuation/frequency distortion;
- compandor linearity;
- harmonic (non-linear) distortion;
- inter-channel crosstalk and circuit transposition;
- inter-channel difference in gain and phase;
- programme modulated and expanded noise;
- received level (insertion gain);
- signal-to-noise ratio (weighted and unweighted).

5.4 Equipment for the measurement of analogue parameters

5.4.1 Recommendation O.41 – Psophometer for use on telephone-type circuits

Recommendation O.41 provides basic requirements for psophometers to be used for the measurement of noise and other interfering signals on telephone-type circuits and circuit sections. Filters for weighted and unweighted noise measurements are specified. Two annexes deal with differences between the ITU-T psophometer and North American weightings and with measurements at interfaces with complex impedances respectively.

5.4.2 Recommendation O.42 – Equipment to measure non-linear distortion using the 4-tone intermodulation method

Recommendation O.42 describes an intermodulation method of testing non-linear distortion using a 4-tone test signal. With regard to the measurement accuracy, this method is superior to simple measurements of the harmonics of a sinusoidal test signal. The four-test signal tones are selected to generate second and third order intermodulation products that occur in the passband of a telephone-type circuit and can be easily separated from the applied test signal.

5.4.3 Recommendation O.61 – Simple equipment to measure interruptions on telephone-type circuits

Recommendation O.61 specifies a simple interruption counter for telephone-type circuits. The instrumentation is capable of measuring interruptions above 3.5 ms using a test tone of 2 kHz.

5.4.4 Recommendation O.62 – Sophisticated equipment to measure interruptions on telephone-type circuits

Recommendation O.62 specifies a sophisticated interruption counter for telephone-type circuits. The instrumentation is capable of measuring interruptions above 0.5 ms using a test tone of 2 kHz.

5.4.5 Recommendation O.71 – Impulsive noise measuring equipment for telephone-type circuits

Recommendation O.71 specifies an instrument capable of assessing the impulsive noise performance of telephone-type circuits. The instrument records the number of times the input signal exceeds a predetermined threshold. The maximum counting rate is 8 counts per second.

5.4.6 Recommendation O.72 – Characteristics of an impulsive noise measuring instrument for wideband data transmissions

Recommendation O.72 specifies an instrument capable of assessing the impulsive noise performance of wideband data circuits. The instrument records the number of times the input signal exceeds a predetermined threshold. Measurement conditions for the following bands are given:

- Baseband (measurement bandwidth of about 48 kHz).
- Group-band (measurement bandwidth of about 40 kHz).
- Supergroup-band (measurement bandwidth of about 238 kHz).

NOTE – The text of Recommendation O.72 conforms to Recommendation H.16 and is published in the CCITT *Red Book*, Fascicle III.4, which was adopted in 1984. Compared with modern technology it is a fairly old specification.

5.4.7 Recommendation O.81 – Group-delay measuring equipment for telephone-type circuits

Recommendation O.81 specifies instrumentation for group-delay measurements on telephone-type circuits. The measurement principle is based upon the so-called Nyquist method using an amplitude-modulated test tone. To overcome the problem of transmitting the reference phase required at the far end of the circuit under test, the measuring signal is periodically replaced by a reference signal at a fixed frequency of 1.8 kHz. Frequency dependent phase and amplitude differences of the envelopes of the measuring and the reference signal are a measure for group-delay and amplitude distortion.

Figure 1 illustrates the test signal structure.

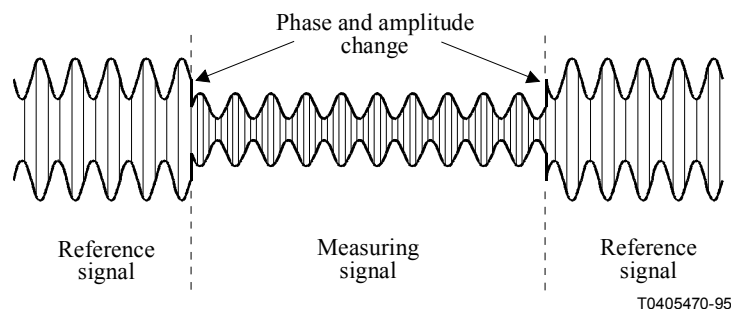


Figure 1/O.1 – Test signal for the measurement of group-delay and amplitude distortion

The instrumentation measures group-delay and gain (loss) variations in the frequency band between 200 Hz and 20 kHz and can be applied to measure and equalize circuits used for data transmission.

ITU-T O.81/Appendix I contains information on a measuring signal (multitone test signal) for fast measurement of amplitude and phase variation on telephone-type circuits. This test signal is not compatible with the one described above.

5.4.8 Recommendation O.82 – Group-delay measuring equipment for the range 5 to 600 kHz

Recommendation O.82 specifies instrumentation for group-delay measurements on group-band circuits. The measurement principle is based upon the so-called Nyquist method using an amplitude-modulated test signal. To overcome the problem of transmitting the reference phase required at the far end of the circuit under test, the measuring signal is periodically replaced by a reference signal at fixed frequencies of 25 kHz, 84 kHz and 432 kHz. Frequency dependent phase and amplitude differences of the envelopes of the measuring and the reference signal are a measure for group-delay and amplitude distortion. The test signal structure is shown in Figure 1.

The instrumentation measures group-delay and gain (loss) variations in the frequency band between 5 kHz and 600 kHz and can be applied to measure and equalize wideband circuits used for data transmission.

It should be noted that Recommendation O.82 found little application because wideband analogue circuits were replaced by digital circuits.

5.4.9 Recommendation O.91 – Phase jitter measuring equipment for telephone-type circuits

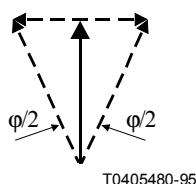


Figure 2/O.1 – Phase modulation representing analogue jitter

Three Recommendations of the O-series deal with jitter measurements, namely Recommendations O.91, O.171 and O.172. These Recommendations serve two different purposes. Recommendation O.91 specifies an instrument intended for the measurement of phase jitter on analogue telephone channels, whereas Recommendations O.171 and O.172 describe equipment for measuring "timing" jitter of digital signals at various bit rates.

Analogue jitter may deteriorate data transmission performance using modems. Timing jitter can result in degraded error performance of digital transmissions systems.

Recommendation O.91 uses a sinusoidal test tone at a frequency of 1 020 Hz and evaluates its phase modulation (phase jitter ϕ – see above Figure 2) in three selectable (side-) bands of 4 to 20 Hz, 4 to 300 Hz and 20 to 300 Hz. In addition, the bands 3 to 300 Hz and 3 to 20 Hz are covered.

5.4.10 Recommendation O.95 – Phase and amplitude hit counters for telephone-type circuits

Phase or amplitude hits are defined as sudden changes in phase or amplitude of an observed test signal which exceed a specified threshold and persist longer than a specified period of time. Phase and amplitude hits may affect data transmission performance using modems.

Recommendation O.95 provides the requirements for an instrument to be used for counting phase and amplitude hits on telephone-type circuits. Both events are counted independently over a given period of time.

5.4.11 Recommendation O.111 – Frequency shift measuring equipment for use on carrier channels

Recommendation O.111 describes a method for measuring the frequency shift introduced by carrier channels. The method uses two test tones at frequencies of 1020 and 2040 Hz. The two frequencies are in exact harmonic relationship. At the receiving end of the channel under test, both frequencies may be shifted by the same amount Δ Hz and the harmonic relationship is no longer maintained. This allows to extract and count the frequency shift Δ Hz.

It should be noted that Recommendation O.111 was published in 1972. Modern frequency measuring devices (e.g. counters) provide other means to measure frequency shift.

5.5 Equipment for the measurement of analogue/digital and digital parameters

Three categories of test equipment are covered in the following subclause, namely:

- 1) Recommendations O.131 to O.133 dealing with performance measurements on devices employing PCM technology and containing A-D and/or D-A converters. The most relevant transmission equipment specifications can be found in Recommendations G.712 [3] and the Q.550-series [4].
- 2) Recommendations O.151 to O.163 specifying instrumentation to assess error performance primarily on PDH systems. Relevant requirements outside the O-series can be found in Recommendations such as G.821 [5], G.826 [6] and M.2100 [7]. Recommendations O.181 and O.191 also deal with error performance measurements but refer to the modern SDH and ATM technique. Background information can be found in Recommendations G.707 [8], G.783 [9], G.784 [10] and M.2101 [11] with regard to SDH and Recommendations I.356 [12], I.361 [14] and I.610 [15] concerning ATM systems.
- 3) Finally, Recommendations O.171 and O.172 specify instrumentation to assess timing jitter. The most important sources are, in this case, Recommendations G.823 [16], G.824 [17] and G.825 [18].

5.5.1 Recommendation O.131 – Quantizing distortion measuring equipment using a pseudo-random noise test signal

Recommendation O.131 specifies instrumentation using a pseudo-random noise stimulus to measure quantizing distortion on devices employing PCM technology. The noise signal has a probability density distribution of amplitudes which is near to a Gaussian distribution and is positioned between 350 and 550 Hz.

At the receiving end, the noise stimulus is suppressed and the quantizing distortion (total distortion) is measured in a band between 800 Hz and 3.4 kHz.

The method described in Recommendation O.131 was in the past required by Recommendation G.712. This is no longer the case and the description of the method has been moved to an appendix of G.712 [3].

5.5.2 Recommendation O.132 – Quantizing distortion measuring equipment using a sinusoidal test signal

Recommendation O.132 specifies instrumentation using a sinusoidal stimulus to measure quantizing distortion on devices employing PCM technology. The test signal frequency is either 850 or 1020 Hz.

At the receiving end, the stimulus is suppressed and the quantizing distortion (total distortion) is measured using psophometric weighting in accordance with Recommendation O.41.

The measurement method is in accordance with the requirements of Recommendation G.712 [3] and the Q.550-Series of Recommendations.

5.5.3 Recommendation O.133 – Equipment for measuring the performance of PCM encoders and decoders

Recommendation O.133 specifies instrumentation for measuring the transmission performance of:

- PCM multiplexers (see Recommendation G.712 [3]);
- digital exchanges (see Q.550-Series of Recommendations [4]);
- transmultiplexers (see Recommendations G.793 [19] and G.794 [20]).

In addition to measurements between analogue interfaces (A-A measurements), the instrumentation allows to measure separately the analogue to digital (A-D) and digital to analogue (D-A) performance of the equipment under test. Digital to digital (D-D) measurements are also possible. The instrumentation is capable of measuring the following parameters using – if applicable – sinusoidal and/or pseudo-random test signals:

- attenuation/frequency distortion;
- crosstalk;
- discrimination against out-of-band input signals;
- frequency of measuring signal;
- gain measurements;
- interference from signalling;
- level measurements;
- longitudinal conversion loss;
- peak code detection;
- relative level;
- return loss at voice-frequency ports;
- single frequency noise;
- spurious out-of-band output signals;
- total distortion (including quantization distortion);
- variation of gain with input level;
- variation of gain with time;
- weighted noise.

Signalling bits and alarms can be monitored and evaluated.

5.5.4 Recommendation O.150 – General requirements for instrumentation for performance measurements on digital transmission equipment

Recommendation O.150 specifies the general properties of digital test sequences for performance measurements on digital transmission equipment. These test sequences are used in a number of O-Series Recommendations.

In addition to the definition of pseudo-random bit sequences so-called "framed" test sequences are described.

To cope with the requirements of Recommendation G.826 [6] (block-oriented error performance measurements), block sizes for various bit rates are given.

Recommendation O.150 contains also information concerning the detection of Loss Of Signal (LOS) and Alarm Indication Signal (AIS).

5.5.5 Recommendation O.151 – Error performance measuring equipment for digital systems at the primary bit rate and above

The instrumentation specified in Recommendation O.151 is designed to measure the bit-error performance of digital systems by the direct comparison of a received pseudo-random test sequence with a locally generated reference sequence identical to the transmitted test sequence.

In addition, the capability to measure errored time intervals is provided.

Test conditions for bit rates between 1544 kbit/s and 139 264 kbit/s are given.

5.5.6 Recommendation O.152 – Error performance measuring equipment for bit rates of 64 kbit/s and $N \times 64$ kbit/s

The equipment specified in Recommendation O.152 is designed to measure bit-error performance of digital paths operating at 64 kbit/s and $N \times 64$ kbit/s by the direct comparison of a received pseudo-random test sequence with a locally generated reference sequence identical to the transmitted test sequence.

5.5.7 Recommendation O.153 – Basic parameters for the measurement of error performance at bit rates below the primary rate

The equipment specified in Recommendation O.153 is designed to measure bit-error performance on circuits operating at bit rates between 50 bit/s and 168 kbit/s. The measurement is based on the direct comparison of a received pseudo-random test sequence with a locally generated reference sequence identical to the transmitted test sequence. Synchronous and asynchronous operation is possible.

5.5.8 Recommendation O.161 – In-service code violation monitors for digital systems

Recommendation O.161 specifies an in-service code violation monitor for the first and second level in the digital hierarchy.

Pseudo-ternary codes to be monitored are Alternate Mark Inversion (AMI), high density bipolar with a maximum of 3 consecutive zeros (HDB 3), B6ZS and B8ZS.

5.5.9 Recommendation O.162 – Equipment to perform in-service monitoring on 2048, 8448, 34 368 and 139 264 kbit/s signals

Recommendation O.162 defines the requirements for an equipment to perform in-service monitoring of digital signals at bit rates of 2048, 8448, 34 368 and 139 264 kbit/s using the frame alignment signal. Frame structures in accordance with Recommendations G.704 [21] and G.751 [22] can be evaluated.

In addition, the equipment measures the error performance by means of the cyclic redundancy check (CRC) procedures and recognizes distant alarms.

5.5.10 Recommendation O.163 – Equipment to perform in-service monitoring on 1544 kbit/s signals

Recommendation O.163 describes frame alignment signal monitoring equipment for 1544 kbit/s frame structures. The equipment is intended to monitor 12-frame multiframe (superframe format) or 24-frame multiframe (extended superframe format) having either AMI or B8ZS line codes.

In addition, the equipment measures the error performance of 24-frame multiframe signals by monitoring the cyclic redundancy check CRC-6 and recognizes distant alarms.

5.5.11 Recommendation O.171 – Timing jitter and wander measuring equipment for digital systems which are based on the Plesiochronous Digital Hierarchy (PDH)

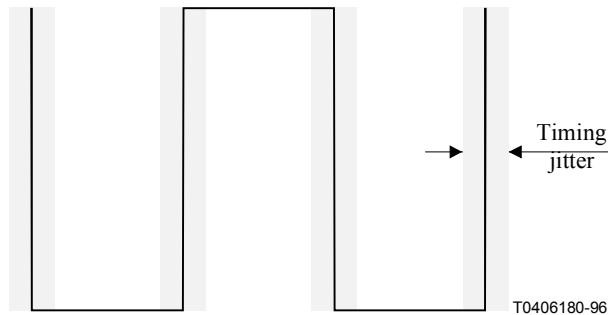


Figure 3/O.1 – Variation of the zero crossings representing timing jitter

Three Recommendations of the O-series deal with jitter measurements, namely Recommendations O.91, O.171 and O.172. These Recommendations serve a different purpose. Recommendation O.91 specifies an instrument intended for the measurement of phase jitter on analogue telephone channels, Recommendation O.171 describes equipment for measuring "timing jitter" of digital signals at various bit rates.

Analogue jitter may deteriorate data transmission performance using modems. Timing jitter can result in degraded error performance of digital transmissions systems.

Recommendation O.171 specifies equipment to measure timing jitter (see above Figure 3) and wander at bit rates from 64 kbit/s to 139 264 kbit/s. In addition, SDH bit rates are covered. The measured jitter amplitude and jitter bandwidth is in accordance with the relevant G-Series Recommendations G.823 [16], G.824 [17] and G.825 [18].

For jitter and wander measurements on SDH equipment see Recommendation O.172.

5.5.12 Recommendation O.172 – Jitter and wander measuring equipment for digital systems which are based on the Synchronous Digital Hierarchy (SDH)

This Recommendation specifies instrumentation that is used to generate and measure jitter and wander in digital systems based on the SDH. Measurement requirements for both SDH line interfaces and SDH tributary interfaces operating at PDH bit rates are addressed in this Recommendation.

The measured jitter amplitude and jitter bandwidth is in accordance with the relevant G-Series Recommendations G.823 [16], G.824 [17] and G.825 [18].

For jitter and wander measurements on PDH equipment see Recommendation O.171.

5.5.13 Recommendation O.181 – Equipment to assess error performance on STM-N interfaces

Recommendation O.181 describes the functions of an equipment capable to assess SDH error performance at STM-N interfaces. The following anomalies and events are monitored to estimate error performance:

Network anomalies:

- Out Of Frame alignment (OOF);
- B1 error;
- B2 error;
- B3 error;
- Higher-order Path Remote Error Indication (HP-REI);
- Lower-order Path Remote Error Indication (LP-REI);
- BIP-2 error.

Network defects

- Loss Of Signal (LOS);
- Loss Of Frame alignment (LOF);
- Multiplex Section Alarm Indication Signal (MS-AIS);
- Multiplex Section Remote Defect Indication (MS-RDI);
- Administrative Unit Loss Of Pointer (AU-LOP);
- Administrative Unit Alarm Indication Signal (AU-AIS);
- Higher-order Path Remote Defect Indication (HP-RDI);
- Tributary Unit Loss of Multiframe alignment (TU-LOM);
- Tributary Unit Loss of Pointer (TU-LOP);
- Tributary Unit Alarm Indication Signal (TU-AIS);
- Lower-order Path Remote Defect Indication (LP-RDI);
- Higher-order Path Trace Identifier Mismatch (HP-TIM);
- Lower-order Path Trace Identifier Mismatch (LP-TIM).

NOTE – See Recommendation G.826 [6] for further details.

5.5.14 Recommendation O.191 – Equipment to measure the cell transfer performance of ATM connections

Recommendation O.191 describes algorithms and processes for the out-of-service estimation of the ATM layer cell transfer performance by means of the network performance parameters defined in Recommendations I.356 [12] and I.357 [13]. Further guidance is provided for in-service measurements and UPC/NPC function performance measurements.

The year 2000 version of Recommendation O.191 is the combination of the Recommendation as approved in April 1997, its Addendum 1, detailing the measurement of error-related and availability-related parameters, as approved in October 1997, and new text covering the measurement of delay-related parameters and UPC/NPC performance.

The measuring equipment defined in Recommendation O.191 evaluates the following performance parameters most of which are taken from Recommendation I.356 [12]:

- 1) *Error related network performance parameters*
 - Cell Error Ratio (CER);
 - Cell Loss Ratio (CLR);
 - Severely Errored Cell Block Ratio (SECBR);
 - Cell Misinsertion Rate (CMR).
- 2) *Delay related performance parameters*
 - Cell Transfer Delay (CTD);
 - Cell Delay Variation (CDV).
- 3) *Availability related network performance parameters*
 - Availability Ratio (AR);
 - Mean Time Between Outages (MTBO).

NOTE – See ITU-T I.356 [12] and ITU-T I.610 [15] for further details.

ANNEX A

Alphabetical list of measurement terms covered by O-Series Recommendations

Term	Reference
A	
A-A tests	3
A-D converters	5.5
A-D tests	3
Administrative Unit Alarm Indication Signal (AU-AIS).....	5.5.13
Administrative Unit Loss of Pointer (AU-LOP).....	5.5.13
AIS	3; 5.5.4
Alarm Indication Signal (AIS), detection of	5.5.4
Alarm monitoring.....	5.5.3
AMI	3
AMI code violations.....	5.5.8
Amplitude hit counter	5.4.10
Analogue-analogue (A-A) measurements	5.5.3
Analogue-digital (A-D) measurements	5.5.3
Asymptotic availability	5.5.14
ATM	3; 5.5

ATM layer performance parameters	
asymptotic availability	5.5.14
Cell Delay Variation	5.5.14
Cell Error Ratio	5.5.14
Cell Loss Ratio	5.5.14
Cell Misinsertion Rate	5.5.14
Cell Transfer Delay	5.5.14
Severely Errored Cell Block Ratio	5.5.14
ATME No. 2	3; 5.2.1
Attenuation/frequency distortion	5.5.3
AU-AIS	3
AU-LOP	3
Automatic Transmission Measuring and signalling testing Equipment, ATME No. 2	5.3.1
B	
B1 error	5.5.13
B2 error	5.5.13
B6ZS code violations	5.5.8
B8ZS code violations	5.5.8
BIP-2 error	5.5.13
Bit error measurements	5.5.5; 5.5.6; 5.5.7
C	
CDV	3
Cell Delay Variation	5.5.14
Cell Error Ratio	5.5.14
Cell Loss Ratio	5.5.14
Cell Misinsertion Rate	5.5.14
Cell Transfer Delay	5.5.14
CER	3
Climates	
Test conditions for indoor climates	5.1.1
Climatic conditions for measuring equipment	5.1.1
Climatic conditions for transportation and storage of measuring equipment	5.1.1

CLR	3
CMR	3; 5.1.14
Code violations	
in-service monitor	5.5.8
monitoring of AMI, HDB3, B6ZS and B8ZS codes	5.5.8
monitoring of pseudo-ternary codes	5.5.8
Common mode rejection (CMR)	5.1.3
Crosstalk.....	5.5.3
CTD	3
Cyclic Redundancy Check	3; 5.5.9; 5.5.10
D	
D-A converters	5.5
D-A tests	3
Data transmission performance	
affected by group-delay or gain variation	5.4.7
affected by phase jitter	5.5.12; 5.5.11; 5.4.9
affected by phase or amplitude hits.....	5.4.10
D-D tests	3
Digital exchanges, testing of.....	5.5.3
Digital-analogue (D-A) measurements	5.5.3
Digital-digital (D-D) measurements.....	5.5.3
Discrimination against out-of-band input signals	5.5.3
E	
Echo canceller tests	5.3.2
diagnostic tests.....	5.3.2
maintenance access lines.....	5.2.1
routine tests	5.3.2
with ATME No. 2	5.3.1
Envelope delay variation.....	5.4.7; 5.4.8
Environmental conditions	5.1.1
Error performance measurements	5.5
Error performance measurements	
at 64 kbit/s and $N \times 64$ kbit/s.....	5.5.6

at the primary bit rate and above.....	5.5.5
between 50 bit/s and 168 kbit/s.....	5.5.7
bit-error measurements	5.5.5; 5.5.6; 5.5.7
Cyclic Redundancy Check	5.5.9; 5.5.10
in-service monitoring at bit rates between 2 and 140 Mbit/s.....	5.5.9
in-service monitoring at bit rates of 1544 kbit/s	5.5.10
pseudo-random test sequences.....	5.5.6; 5.5.5; 5.5.6; 5.5.7
synchronous and asynchronous operation.....	5.5.7
using the frame alignment signal	5.5.9; 5.5.10
F	
Frame alignment signal monitoring	5.5.9; 5.5.10
Frequency shift introduced by carrier channels.....	5.4.11
G	
Gain (loss) variation, measurement of.....	5.4.7; 5.4.8
Group-delay variation, measurement of.....	5.4.7; 5.4.8
H	
HDB 3	3
HDB 3 code violations.....	5.5.8
Higher-order Path Remote Error Indication (HP-REI)	3; 5.5.13
Higher-order Path Trace Identifier Mismatch (HP-TIM).....	5.5.13; 3
HP-RDI	3
I	
ILIL	3; 5.1.3
Impulsive noise measuring equipment for telephone-type circuits.....	5.4.5
Impulsive noise measuring equipment for wideband data transmission.....	5.4.6
Input longitudinal interference loss (ILIL).....	5.1.3
Interference from signalling.....	5.5.3
Intermodulation measurement	
4-tone method	5.4.2
Interruption counter, simple instrument.....	5.4.3
Interruption counter, sophisticated instrument	5.4.4
ISET	3; 5.3.2

J

Jitter

analogue jitter.....	5.4.9; 5.5.11; 5.5.12
Jitter	5.5.11; 5.5.12
jitter amplitude.....	5.5.11; 5.5.12
jitter bandwidth.....	5.4.9; 5.5.11; 5.5.12
timing jitter	5.5.11; 5.5.12

L

LCL	3; 5.1.3
LCTL	3; 5.1.3
Level measurements.....	5.5.3
Longitudinal conversion loss (LCL)	5.1.3; 5.5.3
Longitudinal conversion transfer loss (LCTL).....	5.1.3
LOS	3; 5.5.4
Loss Of Frame alignment (LOF).....	5.5.13
Loss Of Signal (LOS).....	5.5.13
detection of	5.5.4
Lower-order Path Remote Defect Indication (LP-RDI).....	5.5.13
Lower-order Path Remote Error Indication (LP-REI).....	5.5.13
Lower-order Path Trace Identifier Mismatch.....	5.5.13
LP-RDI	3; 5.5.13
LP-REI	3
LP-TIM.....	3; 5.5.13

M

Maintenance access lines	5.2.1
MS-AIS	3; 5.5.13
MS-RDI.....	3
Multiplex section alarm indication signal (MS-AIS).....	5.5.13
Multiplex section remote defect indication (MS-RDI)	5.5.13
Multitone test signal.....	5.4.7

N

Network anomalies.....	5.5.13
------------------------	--------

Nominal reference frequency	5.1.2
Nominal reference level	5.1.2
O	
OOF	3
OSB	3; 5.1.3
Outage intensity.....	5.5.14
Out of frame alignment (OOF).....	5.5.13
Output signal balance (OSB)	5.1.3
P	
PCM encoders/decoders, testing of	
alarm monitoring.....	5.5.3
analogue-analogue (A-A) measurements.....	5.5.3
analogue-digital (A-D) measurements	5.5.3
attenuation/frequency distortion	5.5.3
crosstalk	5.5.3
digital-analogue (D-A) measurements.....	5.5.3
digital-digital (D-D) measurements	5.5.3
discrimination against out-of-band input signals.....	5.5.3
frequency of measuring signal	5.5.3
gain measurements.....	5.5.3
interference from signalling.....	5.5.3
level measurements.....	5.5.3
longitudinal conversion loss	5.5.3
peak code detection.....	5.5.3
pseudo-random test signal.....	5.5.3
quantization distortion	5.5.3
relative level.....	5.5.3
return loss at voice-frequency ports.....	5.5.3
signalling bit monitoring.....	5.5.3
single frequency noise.....	5.5.3
spurious out-of-band output signals.....	5.5.3
total distortion (including quantization distortion).....	5.5.3
variation of gain with input level.....	5.5.3
variation of gain with time.....	5.5.3
weighted noise	5.5.3

PCM multiplexers, testing of	5.5.3
PCM performance measurements	5.5
PDH	3; 5.5.11
PDH systems	5.5
Peak code detection.....	5.5.3
Performance measurements on digital transmission equipment	
block-oriented error performance measurements, block sizes	5.5.4
framed test sequences	5.5.4
general requirements.....	5.5.4
pseudo-random test sequences.....	5.5.4
Phase hit counter	5.4.10
Pseudo-random test sequences.....	5.5.5; 5.5.6; 5.5.7
Pseudo-random test signal.....	5.5.3
Psophometer	
filters for weighted and unweighted noise measurements	5.4.1
interference, measurement of.....	5.4.1
measurements at interfaces with complex impedances	5.4.1
noise, measurement of	5.4.1
North American weighting	5.4.1
weighted noise	5.4.1
Q	
Quantizing distortion, measurement of.....	5.5.1; 5.5.3
using pseudo-random test signal.....	5.5.1
using sinusoidal test signal	5.5.2
R	
Return loss at voice-frequency ports.....	5.5.3
S	
SDH	3; 5.5; 5.5.12
SDH network events	
administrative unit alarm indication signal (AU-AIS).....	5.5.13
administrative unit loss of pointer (AU-LOP)	5.5.13
B1 error	5.5.13
B2 error	5.5.13
BIP-2 error	5.5.13

higher-order path remote error indication (HP-REI)	5.5.13
higher-order path trace identifier mismatch (HP-TIM)	5.5.13
loss of frame alignment (LOF).....	5.5.13
loss of signal (LOS)	5.5.13
lower-order path remote defect indication (LP-RDI).....	5.5.13
Lower-order Path Remote Error Indication (LP-REI)	5.5.13
Lower-order Path Trace Identifier Mismatch (LP-TIM).....	5.5.13
multiplex section alarm indication signal (MS-AIS).....	5.5.13
multiplex section remote defect indication (MS-RDI)	5.5.13
out of frame alignment (OOF)	5.5.13
tributary unit alarm indication signal (TU-AIS)	5.5.13
tributary unit loss of multiframe alignment (TU-LOM)	5.5.13
tributary unit loss of pointer (TU-LOP).....	5.5.13
Severely errored cell block ratio	5.5.14
Signalling bit monitoring	5.5.3
Signalling system functional tests	5.3.1
Signalling system testing and transmission measuring procedures.....	5.3.1
Single frequency noise	5.5.3
Sound programme circuits, testing of	
attenuation/frequency distortion	5.3.3
compandor linearity	5.3.3
harmonic (non-linear) distortion.....	5.3.3
interchannel crosstalk and circuit transposition.....	5.3.3
interchannel difference in gain and phase.....	5.3.3
programme modulated and expanded noise.....	5.3.3
received level (insertion gain).....	5.3.3
signal-to-noise ratio (weighted and unweighted).....	5.3.3
Spurious out-of-band output signals	5.5.3
T	
TCL	3; 5.1.3
TCTL	3; 5.1.3
Test to digital loopback lines	5.3.1
Timing jitter	5.5; 5.5.11; 5.5.12
Total distortion, measurement of	5.5.1; 5.5.2; 5.5.3

Transmission measurements	5.3.1
Transmultiplexers, testing of.....	5.5.3
Transverse conversion loss (TCL)	5.1.3
Transverse conversion transfer loss (TCTL).....	5.1.3
Tributary unit alarm indication signal (TU-AIS)	5.5.13
Tributary unit loss of multiframe alignment (TU-LOM)	5.5.13
Tributary unit loss of pointer (TU-LOP).....	3; 5.5.13
TU-AIS	3
TU-LOM	3
U	
Unbalanced measurements.....	5.1.3
UPC/NPC performance.....	5.5.14
V	
Variation of gain with input level	5.5.3
Variation of gain with time	5.5.3
W	
Wander	5.5.12
Wander measurements	5.5.11; 5.5.12
Weighted noise.....	5.5.3

APPENDIX I

Crosstalk test device for carrier transmission on coaxial systems

(Information from the former USSR Telecommunication Administration)

I.1 Introduction

This appendix contains the description of a method and the basic technical parameters of a device for crosstalk ratio measurement. It is designed for remote localization of repeaters having a low near-end intelligible crosstalk ratio in carrier-transmission coaxial systems.

I.2 Operation

The device measures propagation delay time of near-end crosstalk signals from different repeaters. Measurement of the test signal delay time in order to determine the distance from a repeater and the amplitude of the received signal make it possible to determine the repeater number and the near-end crosstalk ratio of this repeater.

The test signal is extracted from the noise and signals, coming from other repeaters, by means of time filtering (correlation processing). It is preferred that a special signal having a sufficiently narrow correlation function be used as a test signal. A sinusoidal test signal phase-modulated by a Pseudo-Random Sequence (PRS) of pulses (phase-modulated signal) is used in the device.

A simplified block diagram and a frequency diagram of this device are given in Figures I.1 and I.2.

Phase modulation of a sinusoidal signal f_1 from an oscillator G1 by a signal from PRS oscillator G2 is carried out in a modulator M1, the formed signal spectrum having no spectral component f_1 (suppressed by more than 54 dB). The modulating and test signals are shown in Figure I.3, and the modulating signal spectrum is shown in Figure I.4. A phase-modulated test signal in the band from f_{2m} to f_{km} is formed in a modulator M3. A signal from a quartz controlled oscillator at one of the frequencies in the band from f_2 to f_k , which are chosen in the spectrum of transmission systems under test, is used as a carrier. A test signal at $f_{km} \pm f_{1m}$ as well as at f_{1m} contains no central spectral component. The signal f_{km} is applied to the input of an interfering link.

A crosstalk signal from the output of the return path (path subjected to interference) is applied to the input of the device. The signal is reconverted in modulator M4. The signal f_{1m} is then applied to an input of phase detector M2. The PRS signal from G2 shifted by the time interval of Δt with respect to the modulating signal in a time-delay circuit D1 is applied to the other input of the phase detector M2. If the present time interval coincides with the time delay of the crosstalk signal in a line being tested with respect to the test signal at the device output, a single-frequency sinusoidal signal f_1 will be obtained at the output of M2, the signal level then being measured by a Selective Level Meter (SLM). When the present value of Δt does not coincide with the time delay of the crosstalk signal coming from the line, a signal having no frequency f_1 in its spectrum will be present at the output and input of the phase detector M2. By varying the value of the present time delay in D1, tuning to a crosstalk signal from different repeaters on the section under test, a remote measurement of the crosstalk value of all repeaters is carried out.

It is preferred that the choice of parameters of the test signal be determined by the correlation function $R(t)$ of the chosen signal (see Figure I.5). For this purpose, $R(t)$ is estimated at two levels: $R(t) \leq 0.1$ corresponding to the zone of low correlation and $R(t) = 0.607$ limiting the high correlation zone.

Resolution between two adjacent signals is practical if the time shifts between them is outside the zone of high correlation. Therefore, the choice of the duration of an elementary PRS pulse is made depending on the minimum crosstalk time shift Δt_{min} of crosstalk from the adjacent repeaters, namely:

$$\tau \leq \Delta t_{min} = \frac{2l_{RS}}{V}$$

where:

l_{RS} is the minimum distance between the adjacent repeaters;

V is the electric wave propagation rate in the cable.

The pulse duration t in the device depends on the scale oscillator frequency and may be adjusted for various cable types having different propagation rates. Adjustment is carried out by changing the scale oscillator frequency.

The repetition period of a pseudo-random sequence should ensure unambiguity of measurements, i.e. the time between two adjacent autocorrelation function maxima should be greater than the signal propagation time along the section l_{ST} under test in both directions of transmission:

$$T \geq \frac{2l_{ST}}{V}$$

The minimum step of the time-delay circuit D1 is determined by taking into account the admissible error of tuning to the maximum of the autocorrelation function and may be equal to 0.1τ (error not more than 5%). The maximum value of the time delay in D1 is determined by the length of the line section l_{ST} under test, i.e. by the time of signal propagation along the line in both directions of transmission:

$$t_{D1} \geq \frac{2l_{ST}}{V}$$

To measure the crosstalk signal levels corresponding not only to low but also normal crosstalk attenuation of repeaters, the passband of the SLM must be sufficiently narrow (0.1 to 0.3 Hz) so that a test signal may be extracted from the noise. Such a passband may be realized by means of a synchronous phase filter.

I.3 Basic technical parameters of a device designed for transmission systems at frequencies less than 18 MHz

I.3.1 Basic characteristics

- | | | |
|----|-----------------------------------------------------------------------------------------------------|--------------------------------|
| 1) | Maximum length of a section under test | 400 km |
| 2) | Minimum distance between repeaters under test | 1.0 km |
| 3) | Minimum step of setting distance to the repeater under test | 0.1 km |
| 4) | Nominal carrier frequencies of a test signal | 0.37; 1.1; 4.4; 7.9; 17.25 MHz |
| 5) | Minimum measurement level | -120 dB |
| 6) | Time for localization of a faulty repeater (with a maximum of 70 repeaters on a section under test) | 20 min |

I.3.2 Several technical characteristics

- | | | |
|----|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| 1) | Number of elementary pulses in a Pseudo-Random Sequence (PRS) for the test signal phase modulation | $2^9 - 1 = 511$ |
| 2) | PRS repetition rate | 4.2 ms |
| 3) | Test signal level range | -59 dB to 0 dB |
| 4) | Scale oscillator frequency | 2.4 to 2.5 MHz |
| 5) | Level measuring range | -120 to -50 dB |
| 6) | Receiver bandwidth (at a 3 dB level) | 0.3; 3 Hz |
| 7) | Steps of time delay | 83.3 ms (10 km)
8.3 ms (1 km)
0.8 ms (0.1 km) |
| 8) | Reduction in the receiver indicator reading with respect to a value corresponding to the maximum when the PRS is shifted by 24.9 ms (3 km) | more than 40 dB |
| 9) | Measuring error in the "-100 dB" range for the 0 dB reading | less than ± 1 dB |

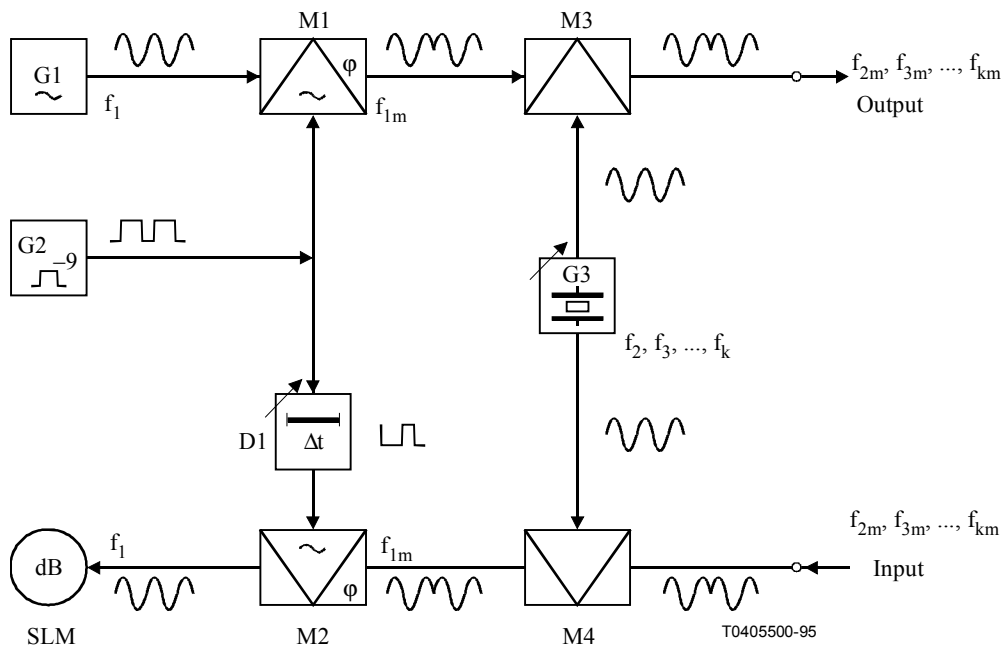


Figure I.1/O.1 – Crosstalk test device simplified block diagram

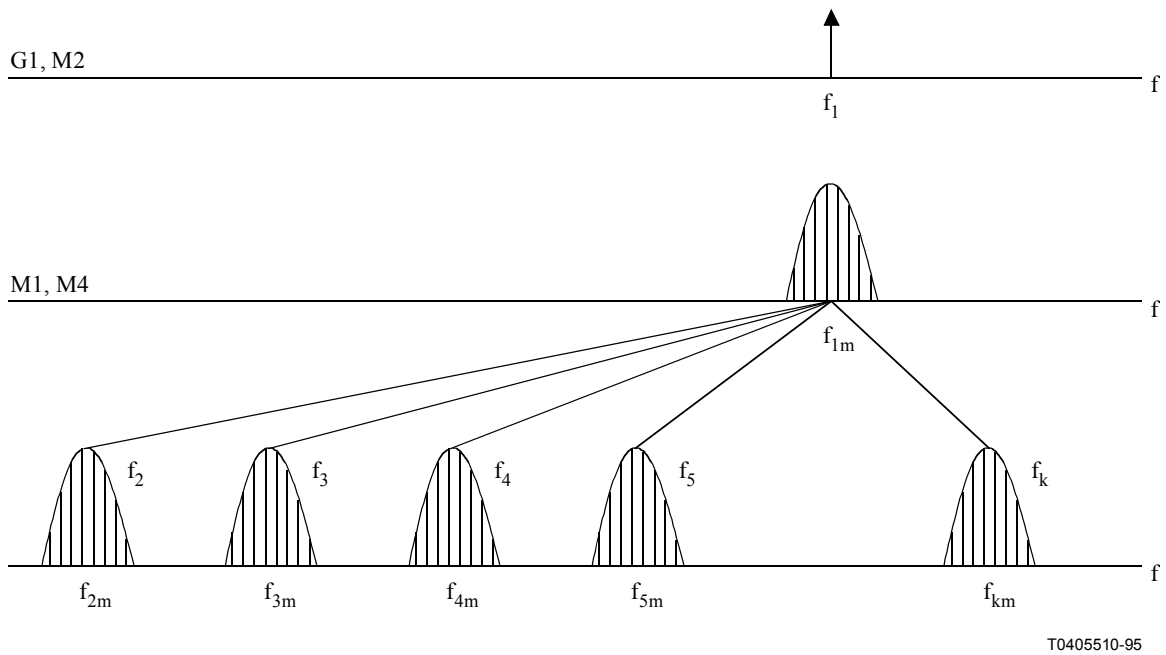


Figure I.2/O.1 – Crosstalk test device frequency diagram

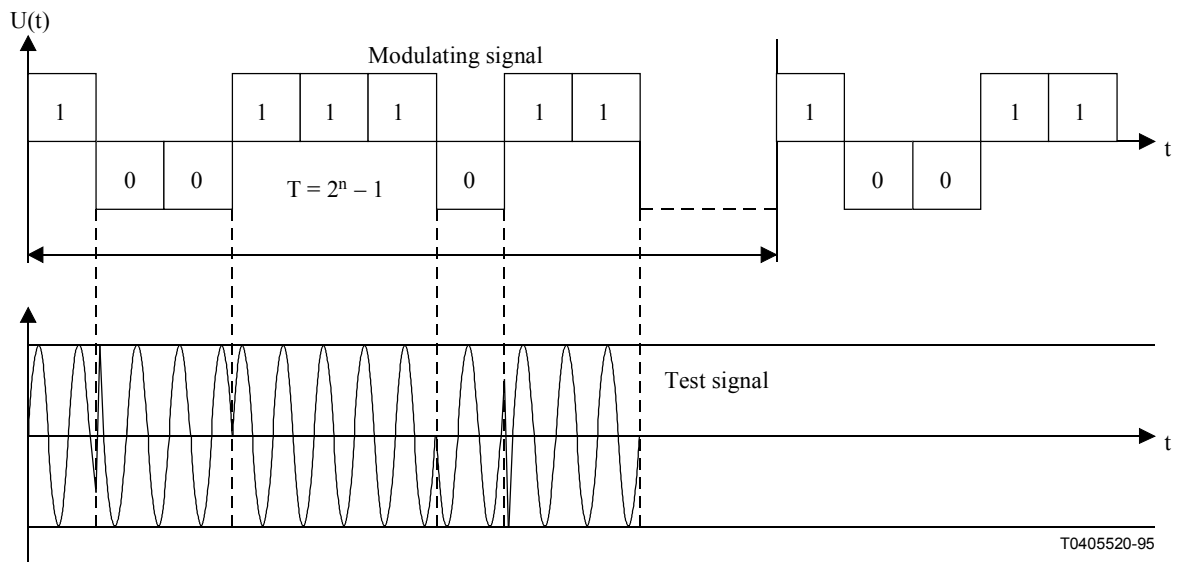


Figure I.3/O.1 – Modulating and test signals

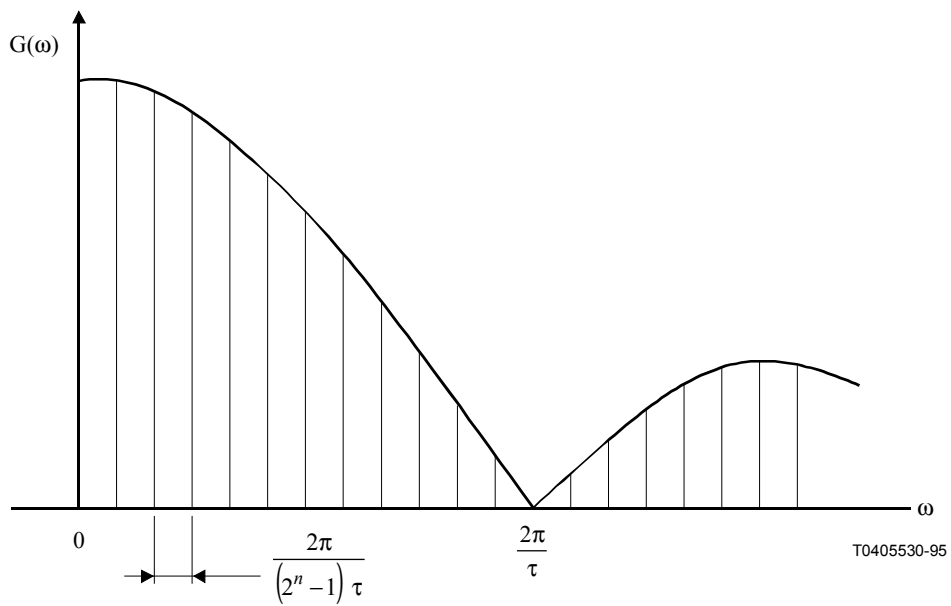


Figure I.4/O.1 – Modulating signal spectrum

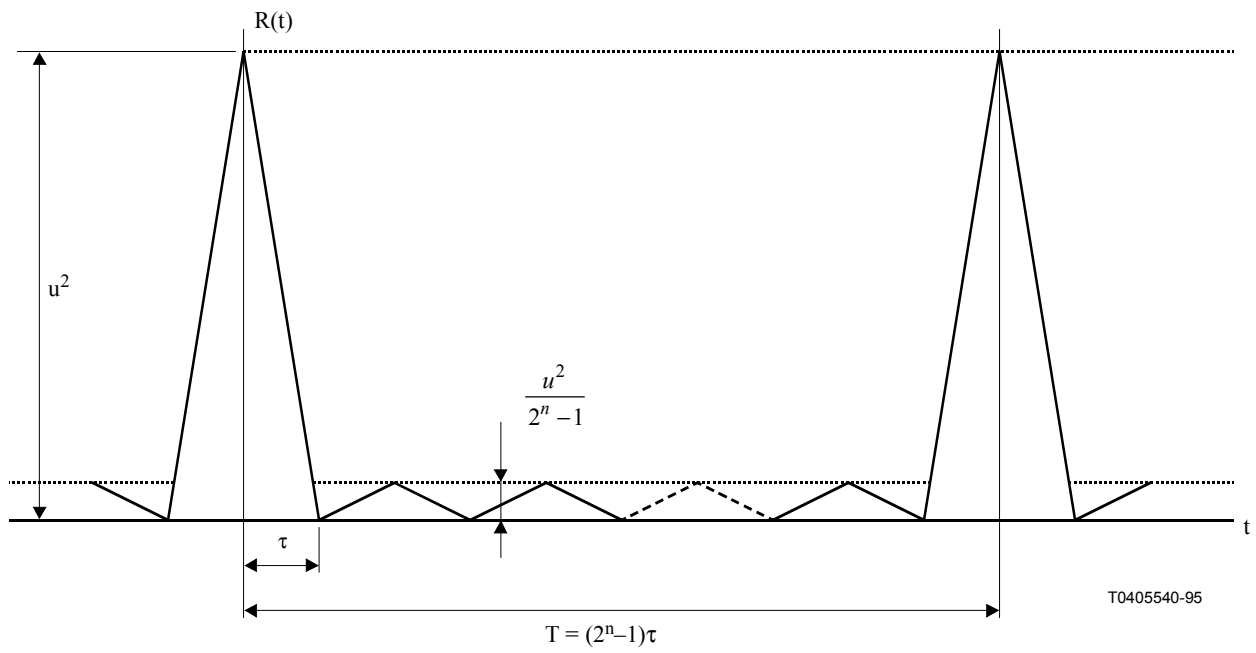


Figure I.5/O.1 – Test signal correlation function

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems