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THE INTERNATIONAL
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CONSULTATIVE COMMITTEE

SPECIFICATIONS OF MEASURING EQUIPMENT

BASIC PARAMETERS FOR THE MEASUREMENT OF ERROR PERFORMANCE AT BIT RATES BELOW THE PRIMARY RATE

Recommendation O.153

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT 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 Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation O.153 was revised by Study Group IV and was approved under the Resolution No. 2 procedure on the 5th of October 1992.

CCITT NOTE

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

Recommendation O.153

BASIC PARAMETERS FOR THE MEASUREMENT OF ERROR PERFORMANCE AT BIT RATES BELOW THE PRIMARY RATE

(Melbourne, 1988; revised 1992)

Abstract

Defines the requirements for equipment to measure error performance at bit rates between 0.050 and 168 kbit/s

Keywords

– digital error detector;

– digital pattern generator;

– error performance measurement;

– measurement;

– tester.

PREAMBLE

The requirements for the characteristics of error measuring equipment which are described below must be adhered to in order to ensure compatibility between equipment produced by different manufacturers.

While requirements are given for the equipment, the realization of the equipment configuration is not covered and should be given careful consideration by the designer and user. In particular, it is not required that all features listed below shall be provided in one piece of equipment. Administrations may select those functions which correspond best to their applications.

When selecting functions, administrations may also consider other Recommendations dealing with error measuring equipment, e.g. Recommendations O.151 [17] and O.152 [18].

1 General

The equipment is designed to measure the error performance on circuits operating at bit rates as defined in § 3. The measurement is based on the direct comparison of specified test patterns which are transmitted through the circuit under test, with identical patterns generated at the receive side. Synchronous and asynchronous operation shall be possible.

2 Test patterns

The following test patterns are recommended (see also Recommendation O.150 [16]).

Note – The use of certain test patterns may be restricted to synchronous or asynchronous operation only. It shall be possible to transmit the patterns for an unlimited time.

2.1 *511-bit pseudo-random test pattern*

This pattern is primarily intended for error measurements at bit rates up to 14.4 kbit/s (see § 3.1).

The pattern may be generated in a nine-stage shift-register whose 5th and 9th stage outputs are added in a modulo-two addition stage, and the result is fed back to the input of the first stage. The pattern begins with the first ONE of 9 consecutive ONES.

Number of shift-register stages	9
Length of the pseudo-random sequence	$2^9 - 1 = 511$ bits
Longest sequence of ZEROs	8 (non-inverted signal)

2.2 *2047-bit pseudo-random test pattern*

If provided, this pattern is primarily intended for error measurements at bit rates of 64 kbit/s and $N \times 64$ kbit/s (see § 3.3).

The pattern may be generated in an eleven-stage shift-register whose 9th and 11th stage outputs are added in a modulo-two addition stage, and the result is fed back to the input of the first stage (see also Recommendation O.152 [18]).

Number of shift-register stages	11
Length of the pseudo-random sequence	$2^{11} - 1 = 2047$ bits
Longest sequence of ZEROs	10 (non-inverted signal)

2.3 *1 048 575 bits pseudo-random test pattern*

This pattern is primarily intended for error measurements at bit rates up to 72 kbit/s (see § 3.2 below).

The pattern may be generated in a twenty-stage shift-register whose 3rd and 20th stage outputs are added in a modulo-two addition stage, and the result is fed back to the input of the first stage.

Number of shift-register stages	20
Length of the pseudo-random sequence	$2^{20} - 1 = 1\,048\,575$ bits
Longest sequence of ZEROs	19 (non-inverted signal)

Note – This test pattern is not identical with the pattern of the same length specified in Recommendation O.151 [17].

2.4 *Fixed test patterns (for continuity tests)*

– Permanent space;

– Permanent mark;

– Alternating space/mark with a ratio of: 1 : 1, 1 : 3, 1 : 7, 3 : 1, 7 : 1;

– "Quick brown fox" – text (QBF) (see Recommendation R.52 [1]) (asynchronous mode only).

2.5 *Programmable test patterns*

A freely programmable pattern with a length of at least 1024 bits is recommended.

2.6 *Loss of sequence synchronization*

Sequence synchronization shall be considered to be lost and resynchronization shall be started if

a) the bit error ratio is ≥ 0.20 during an integration interval of 1 second; or

b) it can be unambiguously identified that the test pattern and the reference pattern are out of phase.

Note – One method to recognize the out-of-phase condition is the evaluation of the error pattern resulting from a bit-by-bit comparison. If the error pattern has the same structure as the pseudo-random test pattern, the out-of-phase condition can be recognized.

This sub-section requires further study.

3 Bit rates

The instrumentation shall provide for measurements at bit rate ranges as specified in the categories below.

3.1 *Data transmission via telephone-type circuits using modems*

– Bit rate range 50 bit/s to 19 200 bit/s.

See Recommendations V.5 [2] and V.6 [3] for details.

Note – Modems operating at bit rates above 14 400 bit/s are not covered by CCITT Recommendations.

3.2 *Data transmission via group-band circuits using wideband modems*

– Bit rate range 48 kbit/s to 168 kbit/s.

See Recommendations V.36 [4] and V.37 [5] for details.

3.3 *Data transmission at and above 64 kbit/s*

With regard to error performance measurements at 64 kbit/s, and $N \times$ 64 kbit/s, relevant information can be found in Recommendation O.152 [18].

Information on measurements at higher bit rates is contained in Recommendation O.151 [17].

3.4 *Deviation from nominal bit rate*

For bit rates up to 9600 bit/s the maximum deviation from the nominal bit rate shall be $\leq$ 0.01% if timing is not derived from the object under test.

For the higher bit rates the maximum deviation shall be $\leq$ 0.002% if timing is not derived from the object under test.

3.5 *Clock sources*

Clock signals are provided through the interface, via an external synchronisation input or from an internal clock generator.

4 Interfaces

Depending on the application and the bit rate, one or several of the following interfaces shall be provided:

– Interface according to Recommendation V.10 (X.26) [6]

– Interface according to Recommendation V.11 (X.27) [7]

– Interface according to Recommendations V.24 [8] and V.28 [9]

– Interface according to Recommendation V.35 [10]

– Interface according to Recommendation V.36 [4]

– Interface according to Recommendations X.21 [11] and X.24 [12].

5 Modes of operation

The instrumentation must fully simulate the characteristics of a DTE and/or a DCE in half duplex and/or full duplex mode. This includes the relevant software or hardware handshaking procedures. In synchronous half duplex mode, the test pattern shall be preceded by two or more leading pads (i.e. characters with alternating mark and space bits) to enable clock recovery. These pads shall be followed by two or more block-synchronization characters.

If the mode of operation requires, it shall be possible to select the parity check conditions even, odd, mark and space.

Note – The insertion of parity check bits is normally not possible when using pseudo-random test patterns.

6 Bit of synchronization

Two modes of synchronization shall be possible:

– Synchronization by means of a timing signal derived from the object under test (e.g. from a modem operating in the synchronous mode).

– Synchronization from the transitions of the received test signal (e.g. when a modem is operating in the nonsynchronous mode).

7 Codes

For encoding the QBF-text (Recommendation R.52 [1]) or a freely programmable pattern, the following data signal code shall be provided:

– CCITT Alphabet No. 5 with 7 bits/character (Recommendation T.50 [13]).

For asynchronous operation 1 or 2 stop bits shall be selectable.

8 Error measurements and error evaluation

8.1 *Bit error measurements*

The range for error ratio measurements shall be 10^{-2} to 10^{-7}. The measurement time shall be sufficiently long to achieve accurate results.

Error ratios smaller than 10^{-7} can be observed by providing the capability to count cumulative errors.

8.2 *Block error measurements*

It shall be possible to perform block error measurements. The block length shall be selectable to 1000 or 10 000 bits or shall be equal to the length of the pseudo-random sequence used for the error test. In addition, a block length of 32 768 bits shall be provided for measurements at bit rates above 14.4 kbit/s.

The range for block error ratio measurements shall be 10^{0} to 10^{-5} with measurement times being sufficiently long to achieve accurate results.

8.3 *Simultaneous measurements*

It shall be possible to perform bit error ratio and block error ratio measurements simultaneously.

8.4 *Error performance evaluation*

The instrumentation shall be capable of detecting errored seconds. The number of errored and error-free time intervals in a selectable time period from 1 minute to 24 hours, or continuous, shall be counted and displayed.

For this measurement the error detection circuits of the instrumentation shall be controlled by an internal timer which sets intervals of equal length and which operates independently of the occurrence of errors.

The measurement of other error performance parameters and the application of Recommendation G.821 [14] are under study.

9 Measurement of distortion

If the instrumentation provides for distortion measurements, the following specifications are applicable.

9.1 *Measurement of individual distortion*

The degrees of early and late individual distortion shall be measured when the instrumentation is operating in the mode in which synchronization is derived from transitions in the received test signal.

When using pseudo-random test signals, the measuring error shall be less than ± 3%.

9.2 *Measurement of bias distortion*

The instrumentation shall measure bias distortion on reversals (alternating space/mark with a ratio of 1 : 1).

In this mode, the measuring error shall be less than ± 2%.

10 Remote control, recording of measurement results

As an option, an interface shall be provided which allows remote control of the instrumentation and further processing of the measuring results.

If provided, the interface shall comply with the interface bus according to IEC Publication 625 [15] or with Recommendation V.24 [8].

11 Operating environment

The electrical performance requirements shall be met when operating at climatic conditions as specified in § 2.1 of Recommendation O.3 [19].

References

[1] CCITT Recommendation R.52 *Standardization of international texts for the measurement of the margin of start-stop equipment.*

[2] CCITT Recommendation V.5 *Standardization of data signalling rates for synchronous data transmission in the general switched telephone network.*

[3] CCITT Recommendation V.6 *Standardization of data signalling rates for synchronous data transmission on leased telephone-type circuits.*

[4] CCITT Recommendation V.36 *Modems for synchronous data transmission using 60-108 kHz group band circuits.*

[5] CCITT Recommendation V.37 *Synchronous data transmission at a data signalling rate higher than 72 kbit/s using 60-108 kHz group band circuits.*

[6] CCITT Recommendation V.10 *Electrical characteristics for unbalanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications.*

[7] CCITT Recommendation V.11 *Electrical characteristics for balanced double-current interchange circuits for general use with integrated circuit equipment in the field of data communications.*

[8] CCITT Recommendation V.24 *List of definitions for interchange circuits between data terminal equipment and data circuit-terminating equipment.*

[9] CCITT Recommendation V.28 *Electrical characteristics for unbalanced double-current interchange circuits.*

[10] CCITT Recommendation V.35 *Data transmission at 48 kbit/s using 60-108 kHz group band circuits.*

[11] CCITT Recommendation X.21 *Interface between data terminal equipment (DTE and data circuit-terminating equipment (DCE) for synchronous operation on public data networks*.

[12] CCITT Recommendation X.24 *List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) on public data networks.*

[13] CCITT Recommendation T.50 *International Alphabet No. 5.*

[14] CCITT Recommendation G.821 *Error performance of an international digital connection forming part of an integrated digital network.*

[15] IEC Publication 625 *An interface system for programmable measuring instruments (byte serial, bit parallel).*

[16] CCITT Recommendation O.150 *Digital test patterns for performance measurements on digital transmission equipment.*

[17] CCITT Recommendation O.151 *Error performance measuring equipment operating at the primary bit rate and above.*

[18] CCITT Recommendation O.152 *Error performance measuring equipment for bit rates of 64 kbit/s and $N \times 64$ kbit/s.*

[19] CCITT Recommendation O.3 *Climatic conditions and relevant tests for measuring equipment.*