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SPECIFICATIONS OF MEASURING EQUIPMENT

ERROR PERFORMANCE MEASURING EQUIPMENT OPERATING AT THE PRIMARY RATE AND ABOVE

Recommendation O.151

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.

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Recommendation O.151 was revised by Study Group IV and was approved under the Resolution No. 2 procedure on the 5th of October 1992.

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CCITT NOTE

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

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Recommendation O.151

ERROR PERFORMANCE MEASURING EQUIPMENT OPERATING AT THE PRIMARY RATE AND ABOVE[1)]

(*Published 1976; revised 1980, 1984, 1988 and 1992*)

Abstract

Defines the requirements for an equipment to measure error performance of digital systems at the hierarchical bit rates between 1.5 and 140 Mbit/s.

Keywords

– digital error detector;
– digital pattern generator;
– error performance measurement;
– measurement;
– tester.

PREAMBLE

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

1 General

The equipment is designed to measure the bit-error performance of digital systems[2)] by the direct comparison of a received pseudo-random test pattern with a locally generated test pattern identical to the transmitted test pattern. In addition, the capability to measure errored time intervals is provided.

2 Test patterns

The following patterns are recommended (see Recommendation O.150 for further details).

2.1 *Pseudo-random pattern for systems using a $2^{15} – 1$ (32 767 bit) pattern length*

This pattern is primarily intended for error and jitter measurements at bit rates of 1544, 2048, 6312, 8448, 32 064 and 44 736 kbit/s.

This pattern may be generated in a fifteen-stage shift register whose 14th and 15th stage outputs are added in a modulo-two addition stage, and the result is fed back to the input of the first stage.

1) This Recommendation is the joint responsibility of Study Groups IV, XVII and XVIII.

2) “Digital system” is used as a generic term for paths, links, transmission systems, etc.

Number of shift register stages	15
Length of pseudo-random sequence	$2^{15} - 1 = 32\ 767$ bits
Longest sequence of ZEROS	15 (inverted signal)

2.2 *Pseudo-random pattern for systems using a $2^{23} - 1$ (8 388 607 bit) pattern length*

This pattern is primarily intended for error and jitter measurements at bit rates of 34 368 and 139 264 kbit/s.

The pattern may be generated in a twenty-three-stage shift register whose 18th and 23rd 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	23
Length of pseudo-random sequence	$2^{23} - 1 = 8\ 388\ 607$ bits
Longest sequence of ZEROS	23 (inverted signal)

2.3 *Pseudo-random pattern for systems using a $2^{20} - 1$ (1 048 575 bit) pattern length*

This pattern is primarily intended for error and jitter measurements at bit rates of 1544, 6312, 32 064 and 44 736 kbit/s.

The pattern may be generated in a twenty-stage shift register whose 17th 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. An output bit is forced to be a ONE whenever the previous 14 bits are all ZERO.

Number of shift register stages	20
Length of pseudo-random sequence	$2^{20} - 1 = 1\ 048\ 575$ bits
Longest sequence of ZEROS	15 (see note)

Note – This test pattern is not identical with the pattern specified in Recommendation O.153 because different feedback mechanisms are used when the patterns are produced by means of shift registers. The pattern specified in this section suppresses consecutive sequences of more than 14 ZEROS.

2.4 *Fixed patterns (optional)*

Fixed patterns of all ONEs (... 1111 ...) and alternating ONEs and ZEROS (... 1010 ...) may be provided.

2.5 *"Framed" measurements*

Certain measurements require that the test pattern is transmitted as "payload" within a valid frame.

In this case, the transmission of the test pattern shall be stopped while framing bits are transmitted.

When using pseudo-random test patterns for framed measurements, the beginning of the test pattern has no fixed relationship with the beginning of a frame.

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 ≥ 0.2 during an integration interval of 1 second; or

b) it can be unambigously 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 the bit-by-bit comparison. If the error pattern has the same structure as the pseudo-random test pattern, then the out-of-phase condition can be recognized.

This sub-section requires further study.

3 Bit rate

The bit rates in accordance with CCITT Recommendations are indicated in Table 1/O.151.

TABLE 1/O.151

Bit rates, pertinent Recommendations and pseudo-random test patterns

Bit rates (kbit/s)	Recommendations corresponding to multiplex system	Recommendations corresponding to digital line section/line system	Bit rate tolerance	Test pattern
1 544	G.733 [1]	G.911 [8], G.951 [9], G.955 [10]	$\pm 50 \cdot 10^{-6}$	$2^{15} - 1$, $2^{20} - 1$
2 048	G.732 [2]	G.921 [11], G.952 [12], G.956 [13]	$\pm 50 \cdot 10^{-6}$	$2^{15} - 1$
6 312	G.743 [3]	G.912 [14], G.951 [9], G.955 [10]	$\pm 30 \cdot 10^{-6}$	$2^{15} - 1$, $2^{20} - 1$
8 448	G.742 [4], G.745 [5]	G.921 [11], G.952 [12], G.956 [13]	$\pm 30 \cdot 10^{-6}$	$2^{15} - 1$
32 064	G.752 [6]	G.913 [15], G.953 [16], G.955 [10]	$\pm 10 \cdot 10^{-6}$	$2^{15} - 1$, $2^{20} - 1$
34 368	G.751 [7]	G.921 [11], G.954 [17], G.956 [13]	$\pm 20 \cdot 10^{-6}$	$2^{23} - 1$
44 736	G.752 [6]	G.914 [18], G.953 [16], G.955 [10]	$\pm 20 \cdot 10^{-6}$	$2^{15} - 1$, $2^{20} - 1$
139 264	G.751 [7]	G.921 [11], G.954 [17], G.956 [13]	$\pm 15 \cdot 10^{-6}$	$2^{23} - 1$

Note – Normally only the appropriate combination of bit rates – either 2048 kbit/s, 8448 kbit/s, etc. or 1544 kbit/s, 6312 kbit/s, etc. – will be provided in a given instrumentation.

4 Interfaces

The interface characteristics (impedances, levels, codes, etc.) should be in accordance with Recommendation G.703 [19].

In addition to providing for terminated measurements, the instrumentation shall also be capable of monitoring at protected test points on digital equipment. Therefore, a high impedance and/or additional gain should be provided to compensate for the loss at monitoring points already provided on some equipment.

5 Error-ratio measuring range

The receiving equipment of the instrumentation should be capable of measuring bit-error ratios in the range 10^{-3} to 10^{-8}. In addition, it should be possible to measure bit-error ratios of 10^{-9} and 10^{-10}; this can be achieved by providing the capability to count cumulative errors.

6 Mode of operation

The mode of operation should be such that the signal to be tested is first converted into a unipolar (binary) signal in the error measuring instrument and subsequently the bit comparison is made also with a reference signal in binary form.

Facilities may optionally be provided to allow the direct comparison at line code (e.g. AMI or HDB3) with correspondingly coded reference signals. In the case of such measurements polarity distinction is possible, so that errors caused by the injection or omission of positive or negative pulses can be determined separately.

7 Measurement of errored time intervals

The instrument shall be capable of detecting errored seconds and other errored or error-free time intervals as defined in § 1.4 of Recommendation G.821 [20] and of deriving error performance reduced to 64 kbit/s in accordance with Annex D to Recommendation G.821 [20][3)]. The number of errored or error-free time intervals in a selectable observation period from 1 minute to 24 hours, or continuous, shall be counted and displayed.

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

8 Operating environment

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

References

[1] CCITT Recommendation G.733 *Characteristics of primary PCM multiplex equipment operating at 1544 kbit/s*.

[2] CCITT Recommendation G.732 *Characteristics of primary PCM multiplex equipment operating at 2048 kbit/s*.

[3] CCITT Recommendation G.743 *Second-order digital multiplex equipment operating at 6312 kbit/s and using positive justification.*

[4] CCITT Recommendation G.742 *Second-order digital multiplex equipment operating at 8448 kbit/s and using positive justification.*

[5] CCITT Recommendation G.745 *Second-order digital multiplex equipment operating at 8448 kbit/s and using positive/zero/negative justification.*

[6] CCITT Recommendation G.752 *Characteristics of digital multiplex equipment based on a second-order bit rate of 6312 kbit/s and using positive justification*.

[7] CCITT Recomendation G.751 *Digital multiplex equipment 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*.

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3) Error performance evaluation at bit rates other than 64 kbit/s is under study.

[8] CCITT Recommendation G.911 *Digital line sections at 1544 kbit/s*.

[9] CCITT Recommendation G.951 *Digital line systems based on the 1544 kbit/s hierarchy on symmetric pair cables*.

[10] CCITT Recommendation G.955 *Digital line systems based on the 1544 kbit/s hierarchy on optical fibre cables*.

[11] CCITT Recommendation G.921 *Digital sections based on the 2048 kbit/s hierarchy*.

[12] CCITT Recommendation G.952 *Digital line systems based on the 2048 kbit/s hierarchy on symmetric pair cables*.

[13] CCITT Recommendation G.956 *Digital line systems based on the 2048 kbit/s hierarchy on optical fibre cables*.

[14] CCITT Recommendation G.912 *Digital line sections at 6312 kbit/s*.

[15] CCITT Recommendation G.913 *Digital line sections at 32 064 kbit/s*.

[16] CCITT Recommendation G.953 *Digital line systems based on the 1544 kbit/s hierarchy on coaxial pair cables*.

[17] CCITT Recommendation G.954 *Digital line systems based on the 2048 kbit/s hierarchy on coaxial pair cables*.

[18] CCITT Recommendation G.914 *Digital line sections at 44 736 kbit/s*.

[19] CCITT Recommendation G.703 *Physical/electrical characteristics of hierarchical digital interfaces.*

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

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