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SPECIFICATIONS FOR MEASURING EQUIPMENT EQUIPMENT FOR THE MEASUREMENT OF DIGITAL AND ANALOGUE/DIGITAL PARAMETERS

EQUIPMENT FOR MEASURING THE PERFORMANCE OF PCM ENCODERS AND DECODERS

ITU-T Recommendation O.133

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. 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, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation O.133 was revised by the ITU-T Study Group IV (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 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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Abstract

Defines the requirements for an equipment to measure the performance of PCM equipments in analogue-to-digital (A-D), digital-to-analogue (D-A), analogue-to-analogue (A-A) and digital-to-digital (D-D) modes.

Key words

Measurement, tester, PCM tester, gain, variation of gain/loss with time, return loss, longitudinal balance, attenuation/frequency distortion, weighted noise, discrimination against out-of-band input signals, spurious out-of-band output signals, single frequency noise, total distortion, variation of gain with input level, crosstalk, interference from signalling, frequency of repetitive signal, load capacity.

Recommendation O.133**EQUIPMENT FOR MEASURING THE PERFORMANCE
OF PCM ENCODERS AND DECODERS***(Published 1984; revised 1988, 1993)***1 Introduction**

1.1 Encoders and decoders conforming to Recommendation G.711 [1] for converting voice-frequency signals to digital (PCM) signals and vice versa are contained in various equipment described by relevant CCITT Recommendations. Examples of these equipment are:

- PCM multiplexers (see Recommendations G.732 [2] and G.733 [3]);
- transmultiplexers (see Recommendations G.793 [4] and G.794 [5]);
- subsystems of digital exchanges (e.g. Recommendations Q.552 [6] and Q.553 [11]).

To ensure that the overall performance limits specified in the CCITT Recommendations are always met where the PCM equipments are interconnected, it is necessary to separately specify and measure the analogue-digital (A-D) and digital-analogue (D-A) performance of the equipment. In addition, analogue-analogue (A-A) and digital-digital (D-D) measurements have to be carried out.

1.2 The measuring instrumentation described below allows these measurements to be made on PCM equipment operating at 2048 kbit/s and/or 1544 kbit/s as specified in Recommendations G.732 [2], G.733 [3], G.793 [4], G.794 [5] and relevant Series Q Recommendations.

2 General**2.1 Measuring functions and physical configuration**

The instrumentation described in this Recommendation consists of the following functional units.

2.1.1 An analogue signal generator to apply voice-frequency signals to the analogue input ports of the equipment under test.

2.1.2 An analogue signal analyzer to process voice-frequency signals received from the analogue output ports of the equipment under test.

2.1.3 A digital signal generator to apply test signals to the digital input ports of the equipment under test.

2.1.4 A digital signal analyzer to process signals received from the digital output ports of the equipment under test.

2.1.5 The four units mentioned in 2.1.1 to 2.1.4 may be provided in any convenient physical arrangement as determined by the supplier.

2.1.6 The functions described in 2.1.3 and 2.1.4 may be realized using either conventional analogue-to-digital and digital-to-analogue conversion techniques, or by direct digital processing techniques.

2.2 Measuring accuracy and compatibility objectives

2.2.1 As a general objective, the accuracy of the measuring instrumentation should be an order of magnitude better than the relevant performance limits of the equipment under test. Due to technical and cost limitations, however, it may not always be possible to meet this objective.

2.2.2 In addition errors may increase if instrumentation of different design is interworking or if the input and output parts of the equipment under test are not accessible at the same location (end-to-end measurements).

2.2.3 Where the test methods of Recommendations such as O.131 [12] or O.132 [13] are referenced below, it should be noted that some of the design requirements of such Recommendations may be insufficient to guarantee the accuracy called for in this Recommendation. Even when observing the specifications of this and other relevant Recommendations (e.g. O.131, O.132), compatibility problems may arise especially when pseudorandom noise signals are used as stimuli leading to reduced measuring accuracy and/or fluctuating results indications.

2.2.4 In order to facilitate interworking of instrumentation of different design, it is recommended to provide pseudorandom noise signals having a specified periodicity (see 3.2.3.1 and 3.4.2.1).

2.3 Measurement capabilities

Table 1 contains a list of parameters which can be measured on the various equipment. In addition, the required measuring configuration is indicated. It should be noted, however, that not all the listed parameters can be measured with the instrumentation specified in this Recommendation. Where applicable, reference is made to other pertinent Recommendations.

TABLE 1/O.133
Measurement capabilities

Parameter	Measuring configuration				Measurement facility
	A-D	D-A	A-A	D-D	
Gain (relationship between encoding law and audio level)	+	+	+	+ ^{a)}	E
Load capacity	+	–	–	–	O
Variation of gain (loss) with time	+	+	+	+	E
Return loss (at voice-frequency ports)	+	+	+	–	O
Longitudinal balance	+	+	+	–	O
Attenuation/frequency distortion	+	+	+	+	E
Weighted noise	+	+	+	+	E
Discrimination against out-of-band input signals	Δ	Δ	Δ	Δ	O
Spurious out-of-band output signals	Δ	Δ	Δ	Δ	O
Single frequency noise	Δ	Δ	Δ	Δ	O
Total distortion (including quantizing distortion)	+	+	+	+	E
Variation of gain with input level	+	+	+	+	E
Crosstalk (measured with sinewave signals) ^{a)}	+	+	+	+	E
Crosstalk (measured with conventional telephone signal)	Δ	Δ	+	Δ	O
Interference from signalling ^{b)}					O
Frequency of repetitive signal	+	+	+	+	O
a) Measurement to be performed while injecting an auxiliary signal in the disturbed channel. b) Stimulus for signalling channel is not specified. E Essential O Optional + – Not applicable Δ Capability not provided NOTES 1 The receive sections of the equipment specified in this Recommendation may be used for level measurements when assessing the Longitudinal Interference Threshold (LIT). 2 Where no symbol is shown, the need for the measurement is under study.					

3 Instrument specifications

In this clause the minimum requirements to be met by the four functional units of the instrumentation are described. The measuring accuracy is covered in clause 4 below.

Measurement functions described in this Recommendation which require pseudo-random noise stimuli are optional.

3.1 Interfaces

3.1.1 Analogue interfaces

3.1.1.1 Output and input impedances, balanced earth free: 600 and/or 900 ohms.

3.1.1.2 Return loss from 200 Hz to 4 kHz: ≥ 36 dB.

3.1.1.3 Longitudinal conversion loss (frequency range 200 Hz to 4 kHz): ≥ 46 dB.

3.1.1.4 Complex impedances

For measurements at interfaces with complex impedances, the instrument shall be equipped with corresponding input impedances. Examples of such impedances are given in Table 1/Q.552 [6].

For this application, the instrument shall be calibrated in accordance with A.3/G.100 [18], namely:

At the reference frequency of 1020 Hz, 0 dBm0 represents an absolute power level of 1 milliwatt measured at the transmission reference point (0 dBr point).

The voltage V of a 0 dBm0 tone at any voiceband frequency is given by the expression:

$$V = \sqrt{1 \text{ W} \cdot 10^{-3} \cdot |Z_{1020}|}$$

where $|Z_{1020}|$ is the modulus of the nominal impedance, Z , at the reference frequency 1020 Hz. Z may be resistive or complex.

3.1.2 Digital interfaces

3.1.2.1 Level conditions and frame format

The instrumentation is required to operate satisfactorily with interface levels in accordance with Recommendation G.703 [7].

One or both of the following conditions of interface and frame formats, including extended frame formats and cyclic redundancy check (CRC) procedures, shall be provided:

At 1544 kbit/s, clause 2/G.703 [7] and Recommendations G.733 [3] and G.704 [10].

At 2048 kbit/s, clause 6/G.703 [7] and Recommendations G.732 [2] and G.704 [10].

Additionally the digital analyzer is required to operate satisfactorily when connected via a length of cable which has an insertion loss of 6 dB at the half bit rate of the signal. The insertion loss of the cable at other frequencies will be proportional to $\sqrt{f}$.

In addition to providing for terminated measurements the instrumentation may also be required to monitor 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.

3.1.2.2 Impedances of digital interfaces

The impedances at the digital outputs and inputs shall conform to clause 2/G.703 and clause 6/G.703 [7].

The return loss measured against the nominal impedance shall be:

- 1544 kbit/s (with pre-emphasis)
 - frequency range 20 kHz to 1.6 MHz at the input: ≥ 20 dB
 - frequency range 20 kHz to 500 kHz at the output: ≥ 14 dB
 - frequency range 500 kHz to 1.6 MHz at the output: ≥ 16 dB

- 1544 kbit/s (without emphasis)

frequency range 20 kHz to 1.6 MHz at both input and output: ≥ 20 dB

- 2048 kbit/s

frequency range 40 kHz to 2.5 MHz at both input and output: ≥ 20 dB

3.1.2.3 Longitudinal conversion loss

(Under study.)

3.2 Analogue signal generator

The following minimum functions shall be provided.

3.2.1 Relative levels

See Recommendation G.232 [8].

3.2.1.1 Relative levels (minimum range): -16 dBr to 0 dBr.

3.2.2 Sinusoidal test signals

3.2.2.1 At levels of 0 and -10 dBm₀, the generator shall produce test signals in the frequency range 200 to 3600 Hz. The frequencies of 3.2.2.2 below, comprising the reference and break points of the relevant masks, shall be provided as a minimum. See 4.1.4 for a note on the choice of test frequencies.

3.2.2.2 Test signal frequencies (approximately): 200 , 300 , 420 , 500 , 600 , 820 , 1020 , 2400 , 2800 , 3000 , 3400 and 3600 Hz.

3.2.2.3 Deviation of transmitted frequency from indicated value f : ± 2 Hz $\pm 0.1\%$ of f .

3.2.2.4 For at least one frequency (preferably approximately 1020 Hz), it shall be possible to adjust the level of the signal between $+3$ dBm₀ and -55 dBm₀. The levels of 3.2.2.5 comprising the reference and break points of the relevant masks shall be provided as a minimum. See 4.1.4 for a note on the choice of test frequencies.

3.2.2.5 Test signal levels: -55 , -50 , -45 , -40 , -30 , -20 , -10 , 0 , $+3$ dBm₀.

3.2.2.6 Deviation of transmitted level from indicated level over the operating range of the instrument: ± 0.2 dB. Means shall nevertheless be provided to make relative measurements as defined in 4.2 within the specified tolerances.

NOTE – This tolerance is specified to facilitate interworking. Deviations in measurement results due to errors in test levels must be considered when reading the measuring accuracies quoted in this Recommendation.

3.2.2.7 Total distortion referred to a measurement bandwidth of 20 kHz is to be at least 20 dB better than the limits given in the diagram of Figure A.5/G.712 [9].

3.2.3 Pseudorandom test signal

3.2.3.1 A pseudorandom test signal in accordance with Recommendation O.131 shall be provided. To facilitate interworking, the sequence repetition rate (period) shall be fixed at 256 ms (2048 samples) derived, where possible, from the sampling rate of the encoder under test. Otherwise, the tolerance shall be ± 1 ms.

NOTE – This requirement is also met by a period of 128 ± 0.5 ms (1024 samples).

3.2.3.2 The level of the pseudorandom test signal shall be adjustable between -3 dBm₀ and -55 dBm₀. The levels of 3.2.3.3 below, comprising the reference and break points of the relevant masks, shall be provided as a minimum.

3.2.3.3 Test signal levels: -55 , -50 , -40 , -34 , -27 , -10 , -6 , -3 dBm₀.

3.2.4 Auxiliary signal

3.2.4.1 In order to increase the accuracy when performing crosstalk measurements, an auxiliary (activating) signal for injection into the disturbed channel shall be provided.

3.2.4.2 Band-limited noise located between 350 and 550 Hz similar to that specified in Recommendation O.131 [12], and having a level in the range -50 to -60 dBm0, may be used as an auxiliary signal. At frequencies below 250 Hz and in the range 700 Hz to 4 kHz, the spurious signal shall be at least 40 dB smaller than the auxiliary signal.

3.2.4.3 As an alternative, a sinusoidal signal having a level in the range -33 to -40 dBm0 may be employed. Harmonic components of the sinusoidal signal shall be at least 40 dB below the fundamental.

3.3 Analogue signal analyzer

The following minimum functions shall be provided.

3.3.1 Relative levels

(See Recommendation G.232 [8].)

3.3.1.1 Relative levels (minimum range): -5 dBr to $+7$ dBr.

3.3.2 Level

3.3.2.1 Level measuring range: -60 to $+5$ dBm0.

3.3.3 Return loss (optional)

3.3.3.1 Return loss measuring range: 0 to 40 dB over the frequency range 200 to 3600 Hz.

3.3.4 Longitudinal balance in accordance with Recommendation O.9 [14] (optional)

3.3.4.1 Longitudinal conversion loss measuring range: 5 to 56 dB, over the frequency range 200 to 3600 Hz.

3.3.4.2 Longitudinal conversion transfer loss measuring range: 5 to 56 dB, over the frequency range 200 to 3600 Hz.

3.3.5 Weighted noise in accordance with Recommendation O.41 [15]

3.3.5.1 Noise measuring range: -80 to -20 dBm0p.

3.3.6 Total distortion in accordance with Recommendations O.131 and/or O.132

NOTE – To facilitate interworking, the observation time for Recommendation O.131 shall be 256 ms or a multiple thereof, derived, where possible, from the sample rate of the decoder under test. Otherwise the tolerance shall be ± 1 ms.

3.3.6.1 Total distortion measuring range: 0 to 40 dB.

3.3.7 Crosstalk

3.3.7.1 Level measuring range: -75 to -20 dBm0.

3.3.8 Frequency of a repetitive signal

As an option, it shall be possible to measure and display the frequency of any repetitive signal in the frequency range 200 and 4000 Hz applied to the input of the instrument at any level in the range defined in 3.3.2. The result shall be displayed to a resolution of 1 Hz. The measurement shall be made to an accuracy of at least $50 \cdot 10^{-6}$.

3.4 Digital signal generator

The following facilities shall be provided by the digital signal generator.

3.4.1 Digitally encoded sine wave signals

3.4.1.1 At levels of 0 and -10 dBm0, digitally encoded sine waves with frequencies in the range 200 Hz to 3600 Hz are to be provided. The frequencies of 3.4.1.2 comprising the reference and break points of the relevant masks, shall be provided as a minimum. See 4.1.4 for a note on the choice of test frequencies.