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SPECIFICATIONS FOR MEASURING EQUIPMENT

EQUIPMENT FOR THE MEASUREMENT OF ANALOGUE PARAMETERS

PSOPHOMETER FOR USE ON TELEPHONE-TYPE CIRCUITS

ITU-T Recommendation O.41

(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.41 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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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.

CONTENTS

Abstract

Defines the basic requirements for an instrument to measure noise and other interfering signals on telephone circuits.

Keywords

Measurement, tester, psophometer, noise measurement, weighting filter.

PSOPHOMETER FOR USE ON TELEPHONE-TYPE CIRCUITS

(Published 1972; revised 1984, 1988, 1993)

1 Introduction

This specification provides basic requirements for psophometers to be used for the measurement of noise and other interfering signals on international telephone circuits and circuit sections.

2 General

To accomplish the measurements as stated above, a psophometer should have the following significant characteristics:

a) The relative sensitivity of the instrument, at various frequencies, should be as specified by the psophometric weighting characteristics.

b) The reference point for the sensitivity of the instrument should be 0 dBm (1 milliwatt) at 800 Hz.

c) The r.m.s. (root mean square) value of the weighted noise signal should be detected and displayed.

d) The dynamics of the detector and display device should meet requirements given in clause 3.

e) The overall accuracy of the instrument when being used in its normal range and environmental conditions should be ± 1.0 dB or better. Specific tests for accuracy of various aspects of the instrument are given in clause 3.

Annex A provides a comparison of the CCITT psophometric and North American (C-message) noise weighting currently in use.

3 Specific requirements

The following provides a minimum set of requirements that should be met by an instrument used as a psophometer.

3.1 Input impedance

All given impedances are for a balanced (earth free) input. The impedance to ground at 800 Hz shall be > 200 kΩ.

3.1.1 Terminating mode

When used in a terminating mode, the input impedance shall be 600 ohms with a return loss of ≥ 30 dB from 300 to 4000 Hz.

3.1.2 Bridging mode

When used in a bridging mode, the tapping loss across 300 ohms shall be ≤ 0.15 dB from 300 to 4000 Hz.

3.1.3 Complex impedances

For measurements at interfaces with complex impedances, the instrument shall be equipped with corresponding input impedances. Examples for such impedances are given in 3.1.8.1/Q.552 and in Figure 12/Q.552 [6].

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

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

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

3.2 Longitudinal losses

Input longitudinal interference loss and longitudinal conversion loss shall be ≥ 110 dB at 50 Hz. This requirement decreases 20 dB per decade to 5000 Hz. (The impressed longitudinal r.m.s. voltage shall not exceed 42 V.)

3.3 Measuring range

The usable measuring range of the instrument shall be –90 to 0 dBm.

3.4 Calibration accuracy at 800 Hz

The output indication shall be 0 dBm ± 0.2 dB with an input signal of 0 dBm at 800 Hz. For other levels over the usable measuring range of the instrument, the measurement error limits shall be as follows:

Range	Error limit
0 to –60 dBm	± 0.5 dB
–60 to –90 dBm	± 1.0 dB

3.5 Relative gain versus frequency (frequency weighting)

The required frequency weighting coefficients and accuracy limits at various frequencies are given in Table 1. In addition, the equivalent noise bandwidth of the weighting network shall be 1823 ± 87 Hz.

Also, the unit may be provided with the 1004 to 1020 Hz test-signal reject filter, described in Table 1/O.132 [4], for use with the characteristics described in Table 1. In this case, the calibration of the measuring instrument shall include a correction factor of appropriate value to account for the loss in effective noise bandwidth due to the test-signal reject filter. The correction factor assumes a uniform distribution of distortion power over the frequency range involved and is of the following form:

3.5.1 Optional frequency characteristic

If desired, the unit may provide the optional frequency response characteristic for unweighted measurements given in Figure 1 in addition to the psophometric weighting of Table 1.

As an additional option, a flat filter with an equivalent noise bandwidth of 3.1 kHz (bandwidth of a telephone channel) is considered desirable for unweighted measurements. If provided, this filter shall have the characteristics of Table 2.

For the measurement of AC hum interference on telephone-type circuits, an optional low pass filter with a cut-off frequency at approximately 250 Hz and an attenuation of ≥ 50 dB at 300 Hz may be provided.

$$\text{Correction} = 10 \log_{10} \frac{\text{Effective bandwidth of standard noise weighting}}{\text{Effective bandwidth of the measuring instrument}} \quad \text{dB}$$

TABLE 1/O.41

Telephone circuit psophometer weighting coefficients and limits

Frequency (Hz)	Relative weight (dB)	Tolerance (± dB)
16.66	−85.0	–
50	−63.0	2
100	−41.0	2
200	−21.0	2
300	−10.6	1
400	−6.3	1
500	−3.6	1
600	−2.0	1
700	−0.9	1
800	0.0	0.0 (Reference)
900	+0.6	1
1000	+1.0	1
1200	0.0	1
1400	−0.9	1
1600	−1.7	1
1800	−2.4	1
2000	−3.0	1
2500	−4.2	1
3000	−5.6	1
3500	−8.5	2
4000	−15.0	3
4500	−25.0	3
5000	−36.0	3
6000	−43.0	–

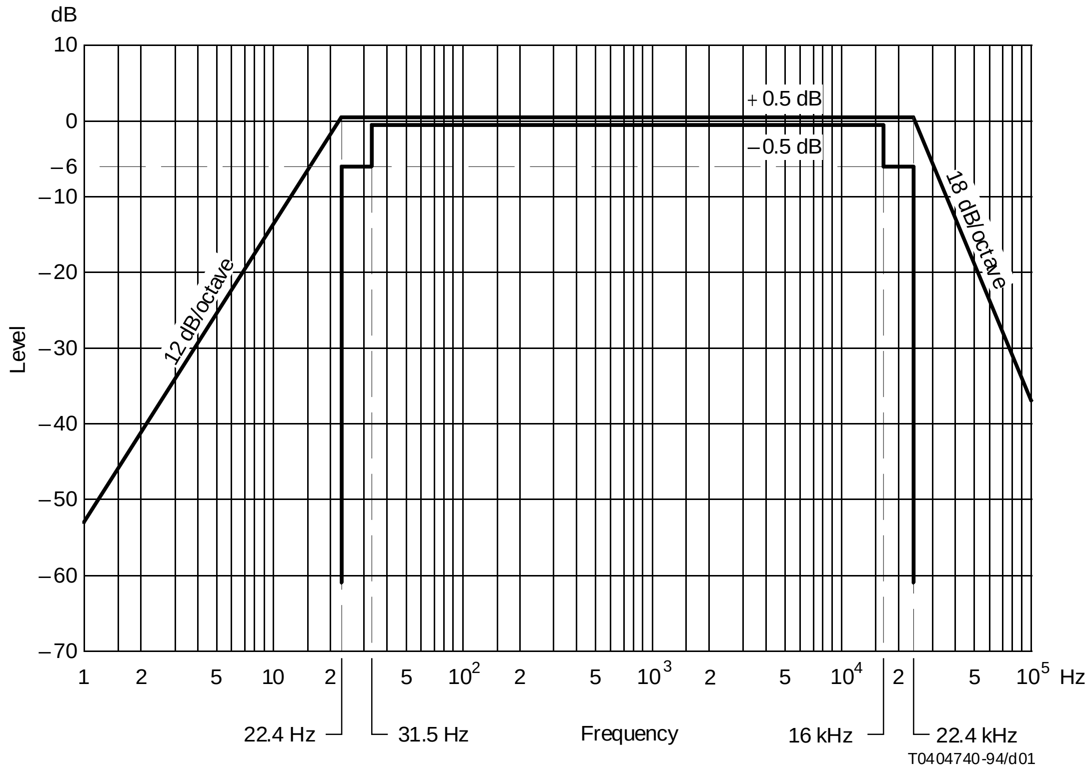

FIGURE 1/O.41

Frequency response characteristics for unweighted measurements

TABLE 2/O.41

Characteristics of the optional flat fitter with an equivalent noise bandwidth of 3.1 kHz (bandwidth of a telephone channel)

Frequency	Attenuation	
< 300 Hz	Increasing	24 dB/octave (Note 1)
300 Hz	Approximately	3 dB (Note 2)
400-1020 Hz		≤ ± 0.25 dB
1020 Hz		0 dB
1020-2600 Hz		≤ ± 0.25 dB
3400 Hz	Approximately	3 dB (Note 2)
> 3400 Hz	Increasing	24 dB/octave (Note 1)

NOTES

1 Below 300 Hz and above 3400 Hz the attenuation shall increase at a slope not less than 24 dB/octave up to an attenuation of at least 50 dB.

2 The exact cutoff frequency shall be chosen to achieve an equivalent noise bandwidth of 3.1 kHz ± 155 Hz.

3.6 Detector circuit characteristics

The detector circuit should measure the r.m.s. value of the noise input. An approximate, or full-wave “quasi” r.m.s. detector may be used if its output does not differ from a true r.m.s. detector by more than ± 0.5 dB for the following signal waveforms:

a) Gaussian noise;

b) sinusoidal signals;

c) any periodic signal having a peak-to-r.m.s. ratio of 8 dB or less.

3.6.1 Detector circuitry tests

The following test is recommended to assure that the detector circuitry is functioning as prescribed.

a) Apply pulses of an 1800 Hz sinewave at a pulse rate of 80 Hz, with 20 percent of the cycle at full amplitude and 80 percent of the cycle 8.4 dB below full amplitude. The indicated r.m.s. value should be 5.0 ± 0.5 dB lower than the level of the ungated full amplitude sinewave.

Alternatively, psophometers manufactured to previous design specifications[1)] shall meet the following test:

b) Successively apply two sinusoidal signals of different frequencies, which are not harmonically related and which provide the same output level on the output indicator. Then apply both these signals at the same levels simultaneously. The increase on the output indicator should be 3 dB ± 0.25 dB above the reading for the single frequency input. This condition should be fulfilled using different pairs of frequencies at different levels.

3.6.2 Turnover

Apply a rectangular waveform with a 20 percent duty cycle and a repetition rate of 600 pulses per second to the input of the instrument, and note the noise reading. Invert the input leads, the two readings shall agree within 1 dB. This test should be performed at several levels over the specified operating range of the set.

1) See Annex A.

3.7 Detector and display dynamics (measurement averaging time)

The response time for the detector and indicating means shall meet one or both of the following requirements.

3.7.1 Instrumentation with continuous signal monitoring

The application of an 800 Hz sinusoidal signal with a duration of 150 to 250 ms should produce an output indication which is the same as that produced by the application of a continuous 800 Hz signal of the same amplitude. Applied signals of shorter duration should produce lower readings on the output indicator.

When performing this test the reading error shall be less than ± 0.2 dB.

3.7.2 Instrumentation with non-continuous signal monitoring

With the application of bursts of 800 Hz tone to the input of the psophometer, gated at a duty cycle of 50%, with half the cycle at full amplitude and the other half down 8.4 dB from full amplitude, the output device shall indicate a variation as shown in Table 3. The levels should be chosen to avoid autoranging points.

TABLE 3/O.41

Variation of the output indication with the application of specified bursts of 800 Hz at the input of the psophometer

Gating frequency	Peak-to-peak indicator variation
25 Hz	≤ 1 dB
5 Hz	≥ 3 dB

It is permissible to adjust the total input power with a 1 dB vernier control to a point where the display does not change so as to pass the less than 1 dB requirement.

3.7.3 Damped response

[Under study.]

3.8 Linearity

The following test is recommended to assure that excessive error is not caused by overload in the presence of signals which have a large peak-to-r.m.s. ratio.

Apply a signal at a frequency of approximately 1000 Hz in 5 ms pulses separated by 20 ms at a r.m.s. level corresponding to the highest value within any selected range of the instrument. When the level is decreased over a range of 10 dB the psophometer reading shall be proportional to the applied level decrease with a tolerance of ± 0.5 dB, for all ranges of the instrument.

3.9 Output indicator

If an analogue meter is used, the spacing of the meter markings shall be 1 dB or less over the normally used portion of the meter scale.

If a digital display is used, the noise reading shall be displayed to the nearest 0.1 dB. The result shall be rounded rather than truncated. The update rate for a digital display shall be at least once per second.

Optionally, instruments using digital displays may provide additional display characteristics to expand the application of the instrument. Such additional display characteristics shall be defined by the manufacturer to assist the user in interpreting the results.

3.10 Operating environment

The electrical performance requirements shall be met when operating at the climatic conditions as specified in 2.1/O.3 [5].

3.10.1 Immunity to electromagnetic fields

The unit should not be affected by the presence of electromagnetic fields (50 Hz). The test for this immunity is given below.

a) With the instrument in the weighted measurement mode, an electromagnetic field strength of 16 A/m at 50 Hz shall cause an output indication of less than –85 dBm.

b) With the instrument in an unweighted measurement mode (optional, see 3.5.1), an electromagnetic field strength of 0.8 A/m at 50 Hz shall cause an output indication of less than –85 dBm.

Annex A

Comparison of CCITT and North American weightings

(This annex forms an integral part of this Recommendation)

Telephone circuit noise impairment is normally measured with “C-message” weighting within the North American domestic telephone networks [1], [2]. The frequency response of this weighting differs somewhat from the CCITT psophometric weighting specified in this Recommendation. As a consequence, the relationship between measurements made with the North American noise meter and the CCITT psophometer is dependent on the frequency spectrum of the noise being measured. In addition, it should be noted that measurements made with the North American noise meter are expressed in **dBrn** (decibels referred to –90 dBm or decibels above a reference power of 10^{-12} watts). For example, if 1 ne milliwatt of white noise in the 300 to 3400 Hz band is applied to both a CCITT psophometer and a North American noise meter, the following readings are obtained:

CCITT psophometer (1951 weighting)	–2.5 dBm
North American noise meter (C-message weighting)	88.0 dBrn.

Recognizing that the relationship of the output readings of the differently weighted instruments will change for other noise spectra, the following rounded conversion formula is proposed for practical comparison purposes:

Psophometer reading (in dBm) = C-message noise meter reading –90 (in dBrn)

This conversion includes the effect of the difference between the reference frequencies (800 Hz for psophometric weighting and 1000 Hz for C-message weighting) used in the two types of noise meters.

The C-message weighting coefficients and accuracy limits at various frequencies are given in Table A.1. A comparison between psophometric and C-message weighting is shown on Figure A.1.

Another weighting frequently used for measuring telephone circuit noise impairment within the North American domestic telephone networks is referred to as “3 kHz Flat” weighting [1]. This weighting is intended for the investigation of the presence of low-frequency noise (power induction, etc.) on the circuit under test. It is characterized as a 3 kHz low-pass weighting of Butterworth shape attenuating above 3 kHz at 12 dB per octave. The specification for this weighting is given in Table A.2.

TABLE A.1/O.41

C-message weighting coefficients and accuracy limits

Frequency (Hz)	Relative weight (dB)	Tolerance (± dB)
60	–55.7	2
100	–42.5	2
200	–25.1	2
300	–16.3	2
400	–11.2	1
500	–7.7	1
600	–5.0	1
700	–2.8	1
800	–1.3	1
900	–0.3	1
1000	0.0	0.0 (Reference)
1200	–0.4	1
1300	–0.7	1
1500	–1.2	1
1800	–1.3	1
2000	–1.1	1
2500	–1.1	1
2800	–2.0	1
3000	–3.0	1
3300	–5.1	2
3500	–7.1	2
4000	–14.6	3
4500	–22.3	3
5000	–28.7	3
NOTE – The attenuation shall continue to increase above 5000 Hz at a rate of not less than 12 dB per octave until it reaches a value of –60 dB.		

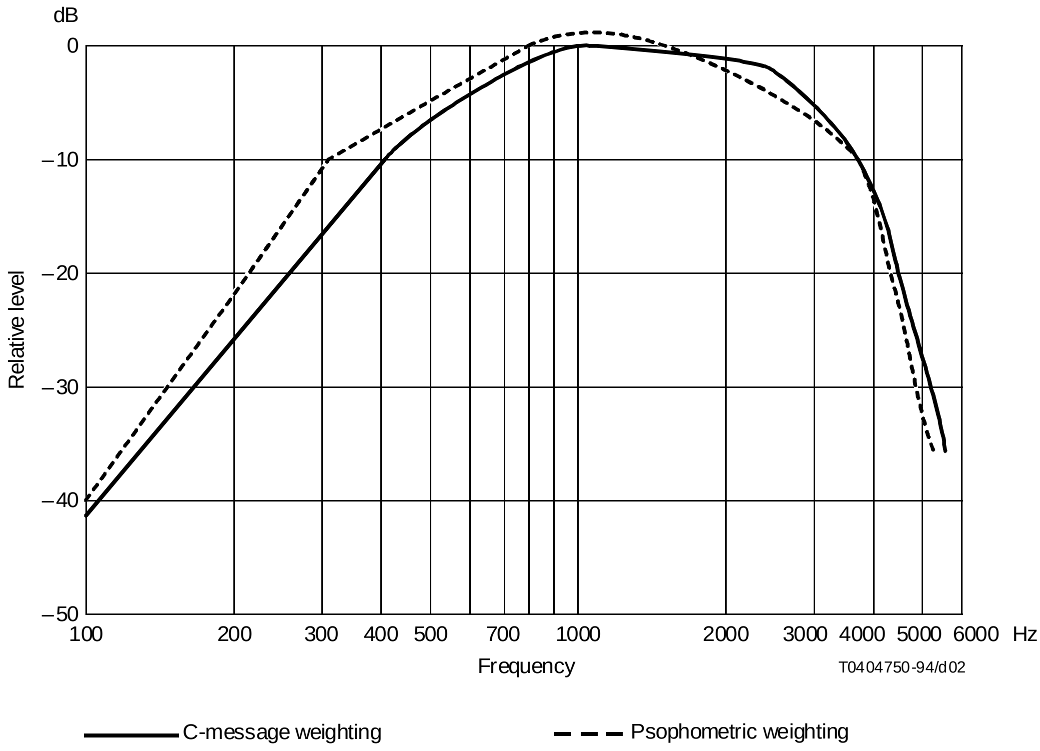

FIGURE A.1/O.41

Comparison between psophometric and C-message weighting

TABLE A.2/O.41

3 kHz flat weighting characteristic

Frequency (Hz)	30	60	400	1000	2000	3000	6000
Relative loss (dB)	0	0	0	0	0.8	3.0	12.3[a)]
Tolerance (dB)	± 2.5	± 1.7	± 0.5	± 0.2	± 1.0	± 1.8	± 3.0

a) The loss shall continue to increase above 6000 Hz at a rate of not less than 12 dB per octave until it reaches a value of 60 dB. The loss at higher frequencies shall be at least 60 dB.

References

[1] CCITT Recommendation *Circuit noise in national networks*, Rec. G.123, Annex A.

[2] *Noise Measuring Instruments for Telecommunication Circuits*, CCITT *Green Book*, Vol. IV.2, Supplement 3.2, ITU, Geneva, 1973.

[3] CCITT Recommendation *Definitions used in Recommendation on general characteristics of international telephone connections and international telephone circuits*, Rec. G.100 (subclause A.3).

[4] CCITT Recommendation *Quantizing distortion measuring equipment using a sinusoidal signal*, Rec. O.132.

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

[6] CCITT Recommendation *Transmission characteristics at 2-wire analogue interfaces of digital exchanges*, Rec. Q.552.

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