INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

P.81

(03/93)

TELEPHONE TRANSMISSION QUALITY

SUBJECTIVE OPINION TESTS

MODULATED NOISE REFERENCE UNIT (MNRU)

ITU-T Recommendation P.81

(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 P.81 was revised by the ITU-T Study Group XII (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 Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.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

Recommendation P.81[1)]

MODULATED NOISE REFERENCE UNIT (MNRU)

(Malaga-Torremolinos, 1984; amended Melbourne, 1988; Helsinki, 1993)

The CCITT,

considering

(a) that the use of digital processes (64 kbit/s PCM A-law or μ-law, A/D/A encoder pairs, A/μ-law or μ/A-law converters, digital pads based on 8-bit PCM words, 32 kbit/s ADPCM, etc.) in the international telephone network has grown rapidly over the past several years, and this growth is expected to continue;

(b) that new digital processes are being standardized, e.g. 64 kbit/s 7 kHz wideband ADPCM;

(c) that there is a need for standard tools to measure the quantization distortion performance of digital processes [for example, 32 kbit/s ADPCM (Recommendation G.726) and 64 kbit/s 7 kHz wideband codec (Recommendation G.722)], so that the tools can be used for estimating the subjective transmission performance of international connections containing digital processes;

(d) that an objective speech quality assessment method has not yet been established;

(e) that, at the present time, subjective tests incorporating reference system conditions represent the only suitable method for measuring the speech transmission performance of digital processes;

(f) that expressing results in terms of a common reference system may facilitate comparison of subjective test results obtained at different laboratories,

recommends

(1) the use of a narrow-band Modulated Noise Reference Unit (MNRU) as the reference system in terms of which subjective performance of telephone bandwidth digital processes should be expressed;

(2) the use of a wideband MNRU as the reference system in terms of which subjective performance of wideband digital processes should be expressed[2)].

NOTES

1 The MNRU can be realized using laboratory equipment or by computer simulation. Further information on the MNRU is given in the references listed at the end of this Recommendation.

2 The listening-only method presently proposed when using the MNRU in subjective tests is described in Recommendation P.83. See 2.2/P.80 for precautions concerning the use of listening-only tests.

3 Objective measurement methods which suitably reflect subjective quantization distortion performance of various types of digital processes do not exist at present. (For example, the objective technique of Recommendation G.712, based on sine-wave and band-limited noise measurements, are designed for PCM and do not measure appropriately the distortion induced by other systems such as ADPCM.) The artificial voice described in Recommendation P.50 may be relevant. Even if an objective method is developed, subjective tests will be required to establish correlation of subjective results/objective results for particular digital process types.

4 The wideband MNRU without noise shaping as described in this Recommendation is recommended[2)]. Administrations are asked to comment on the need for a filter in the noise path after the multiplier (see Supplement No. 15 to Series P Recommendations), to shape the correlated noise spectrum. Some Administrations suggest the use of such a filter while others do not.

[1)] This Recommendation was numbered P.70 in the *Red Book*.

[2)] This specification is subject to future enhancement and therefore should be regarded as provisional.

1 Introduction

The MNRU was originally devised to produce distortion subjectively similar to that produced by logarithmically companded PCM systems [1]. This approach was based on the views:

1) that network planning would require extensive subjective tests to enable evaluation of PCM system performance over a range of compandor characteristics, at various signal levels and in combination with various other transmission impairments (e.g. loss, idle circuit noise, etc.) at various levels; and

2) that it would be as reliable and easier to define a reference distortion system, itself providing distortion perceptually similar to that of PCM systems, in terms of which the performance of PCM systems could be expressed. This requires extensive subjective evaluation of the reference system when inserted in one or more simulated telephone connections, but leads to the possibility of simplified subjective evaluation of new digital processing techniques.

Various organizations (Administrations, scientific/industrial organizations), as well as the CCITT itself, have made extensive use of the MNRU concept for evaluating the subjective performance of digital processes (in arriving at Recommendations G.726 32 kbit/s ADPCM and G.722, for example). A modified version for use in evaluating codecs of wider bandwidth (70-7000 Hz) is now common practice. However, the actual devices used, while based on common principles, may have differed in detail, and hence the subjective results obtained may also have differed. (Differences in subjective testing methodology are also relevant.) The purpose of this Recommendation is to define the narrow-band and wideband versions of the MNRU as completely and in as much detail as possible in order to minimize the effects of the device, and of its objective calibration procedures, on subjective-test results.

2 General description

Simplified arrangements of the MNRU are shown in Figure 1a) for the narrow-band version and Figure 1b) for the wideband version. Speech signals entering from the left are split between 2 paths, a signal path and a noise path. The signal path provides an undistorted (except for bandpass filtering) speech signal at the output. In the noise path, the speech signal instantaneously controls a multiplier with an applied gaussian noise "carrier" which has a uniform spectrum between 0 Hz and a frequency at least twice the cutoff frequency of the lowpass portion of the bandpass filter. The output of the multiplier consisting of the noise modulated by the speech signal, is then added to the speech signal to produce the distorted signal.

The attenuators and switches in the signal and noise paths allow independent adjustment of the speech and noise signal levels at the output. Typically, the system is so calibrated that the setting of the attenuator (in dB) in the noise path represents the ratio of instantaneous speech power to noise power, when both are measured at the output of the band-pass filter (terminal OT).

For this Recommendation, the decibel representation of the ratio is called Q_N for the narrow-band version and Q_W for the wideband version.

3 Performance specifications

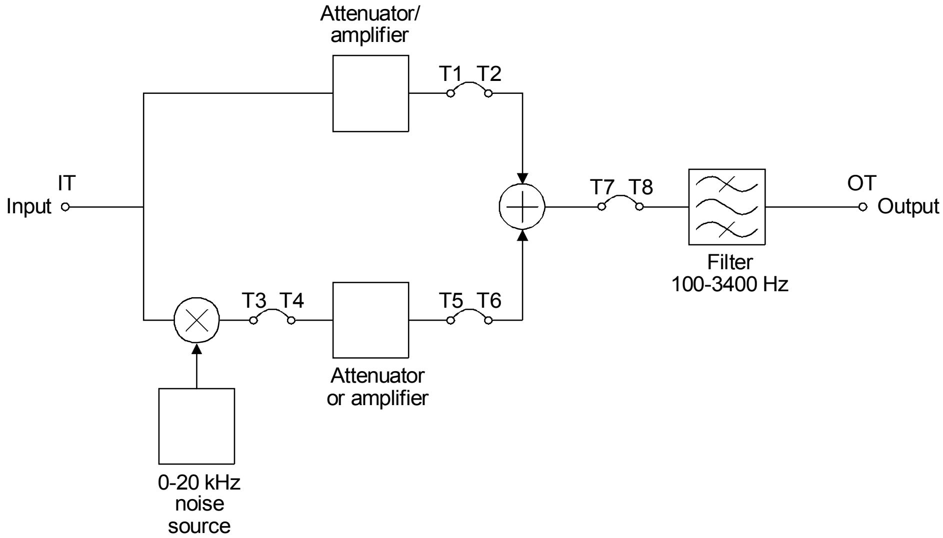
3.1 General

The specifications in this subclause apply both to hardware implementations and software simulations.

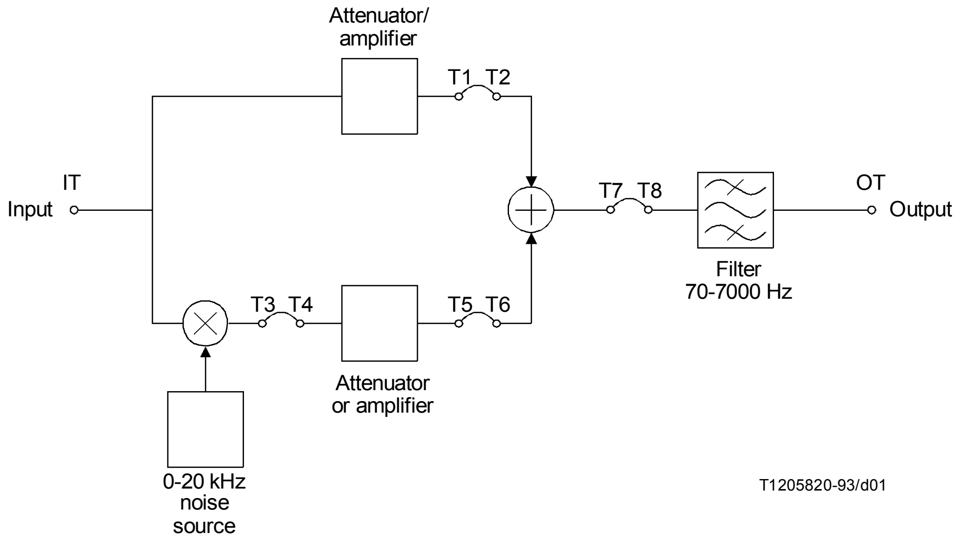
For practical implementations, the actual signal levels and noise levels may be increased or decreased to meet special needs. In such cases, the level requirements detailed below will have to be modified accordingly.

3.2 Signal path

The requirements under this heading refer to the MNRU with infinite attenuation in the noise paths of Figure 1; separate resistive terminations at the terminals T5 and T6 (unlinked) will achieve this.



a) Basic arrangement of narrow-band MNRU



b) Basic arrangement of wideband MNRU

FIGURE 1/P.81

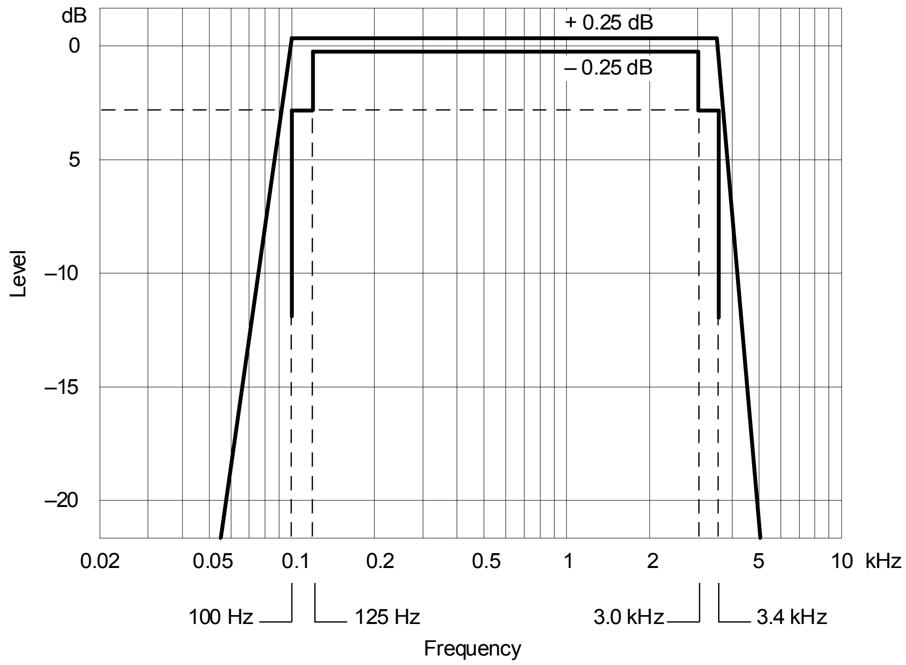
The frequency response of the signal path (i.e. between terminals IT and OT of Figures 1a) and 1b) should be within the limits of Figure 2a) for the circuit of Figure 1a) and within the limits of Figure 2b) for the circuit of Figure 1b).

The loss between terminals IT and OT for a 0 dBm, 1 kHz input sine wave should be 0 dB. Over the input level range +10 dBm to –50 dBm, the loss should be 0 dB ± 0.1 dB.

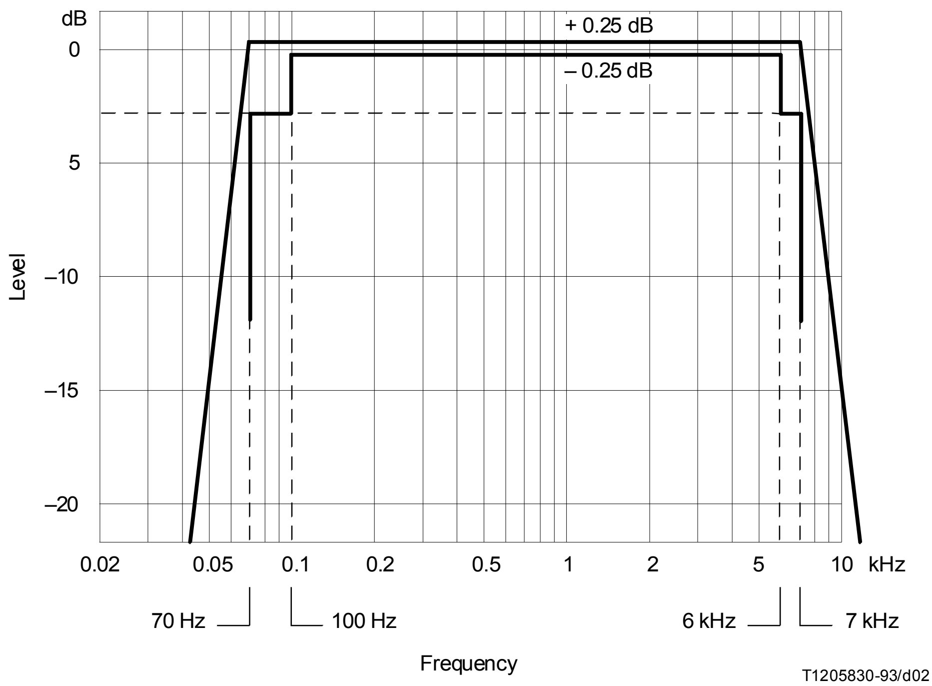
Any harmonic component should be at least 50 dB below the fundamental at the system output (terminal OT in Figures 1a) and 1b) for any fundamental frequency between 125 Hz and 3000 Hz in a narrow-band system and 100 Hz and 6000 Hz in a wideband system.

The idle noise generated in the signal path must be less than –60 dBm, measured at terminal OT, in order to conform with 3.4.

It is recommended that the level of speech signals applied to the terminals IT should be less than –10 dBm (mean power while active, i.e. mean active level according to Recommendation P.56) in order to avoid amplifier peak-clippings of the signal, and be greater than –30 dBm to ensure sufficient speech signal-to-noise ratio.



a) Requirements for output filter of the narrow-band MNRU



b) Requirements for output filter of the wideband MNRU

FIGURE 2/P.81

3.3 Noise path

The requirements under this heading refer to the MNRU with infinite attenuation inserted into the signal path of Figure 1; separate resistive terminations at the terminals T1 and T2 (unlinked) will achieve this.

3.3.1 Linearity as function of input level

With a Q_N setting of 0 dB in the circuit of Figure 1a), or a Q_W setting of 0 dB in the circuit of Figure 1b), as the case may be, the noise level at the system output (terminal OT) should be numerically equal to the sine wave level at the input terminal (terminal IT). A correspondence within ± 0.5 dB should be obtained for input levels from +5 dBm to –45 dBm, and for input frequencies from 125 Hz to 3000 Hz in a narrow-band system and 100 Hz to 6000 Hz in a wideband system.

3.3.2 Noise spectrum

For a narrow-band system, when Q_N is set to 0 dB, input sine waves applied to terminal IT in Figure 1a) with levels from +5 to –45 dBm and frequencies from 125 Hz to 3000 Hz should result in a flat noise system spectrum density at the output of the multiplication device (terminal T3 of Figure 1a)) within ± 1 dB over the frequency range 75 Hz to 5000 Hz. The spectrum density should be measured with a bandwidth resolution of maximum 50 Hz.

For a wideband system, when Q_W is set to 0 dB, input sine waves applied to terminal IT in Figure 1b) with levels from +5 to –45 dBm and frequencies from 100 Hz to 6000 Hz should result in a flat noise system spectrum density at the output of the multiplication device (terminal T3 of Figure 1b)) within ± 1 dB over the frequency range 75 Hz to 10 000 Hz. The spectrum density should be measured with a bandwith resolution of maximum 50 Hz.

3.3.3 Amplitude distribution

The amplitude distribution of the noise at the system output should be approximately gaussian.

NOTE – A noise source consisting of a gaussian nose generator followed by a peak clipper with a flat spectrum from near zero to 20 kHz will produce a satisfactory output noise at terminal OT.

3.3.4 Noise attenuators

The loss of the noise attenuator(s) i.e. between terminals T4 and T5 in Figures 1a) and 1b), should be within ± 0.1 dB of the nominal setting. The attenuator(s) should at least allow Q_N and Q_W settings in the range –5 dB to 45 dB, i.e. a 50 dB range.

3.4 Combined path

The requirements under this heading refer to the MNRU with both speech and noise paths simultaneously in operation.

With Q_N or Q_W (as the case may be) set to zero, and the input terminated by an equivalent resistance, the idle noise generated in the combined path should be less than –60 dBm when measured at the system output (terminal OT).

References

[1] LAW (H. B.), SEYMOUR (R. A.): A reference distortion system using modulated noise, *The Institute of Electrical Engineers*, pp. 484-485, November 1962.

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