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OF ITU

**Series P**
**Supplement 10**
(11/88)

SERIES P: TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS

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# Considerations relating to transmission characteristics for analogue handset telephones

ITU-T P-series Recommendations
Supplement 10

(Previously CCITT Recommendations)

ITU-T P-SERIES RECOMMENDATIONS

**TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS**

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The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

## CONTENTS

# CONSIDERATIONS RELATING TO TRANSMISSION CHARACTERISTICS FOR ANALOGUE HANDSET TELEPHONES

*(Malaga-Torremolinos, 1984; amended Melbourne, 1988)*

## 1 Introduction

This Supplement based on reference [9] summarizes available information on how some characteristics for handset telephones can be optimized.

It contains information about sending and receiving sensitivities, frequency responses, sidetone characteristics, influence of impedance and handset dimensions. It must be remembered that there are different ways to make an optimization. For instance the number of degrees of freedom are essential. As there are different opinions in different countries (for instance, the different assumptions made) the results of the optimization will be different. This Supplement touches some of these aspects.

## 2 Receiving frequency response

Most Administrations seem to prefer a fairly flat frequency response between 300 Hz and 3400 Hz. This probably derives from the early days of telephone networks, when it was determined that possible pre-emphasis at higher frequencies should be located at the sending end to obtain the best possible overall signal-to-noise performance. If we consider free-field, two-ear listening as a reference (face to face conversation) and assume a frequency-independent (flat) response, we should in principle simulate these conditions also at one-ear telephone listening.

Then, at the earphone listening, we should have a frequency response of the earphone as in Figure 1 to simulate the diffraction effect we have at free-field two-ear listening [1]. However, most Administrations seem to prefer a flat response and to put the corresponding correction at the sending end. It may also be easier to construct a receiver with high efficiency if the goal is a flat response. Reference [2] has suggested a response as in Figure 2 optimized for a mean local line. Where mains noise may cause problems, a response with greater loss at lower frequencies, e.g. at 200 Hz and lower frequencies, may be appropriate.

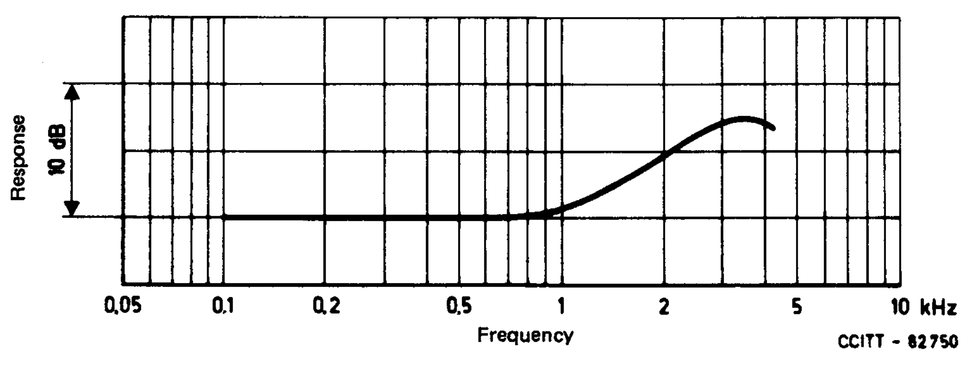


FIGURE 1

**The diffraction effect around the head at 1 m distance in free field [1]**

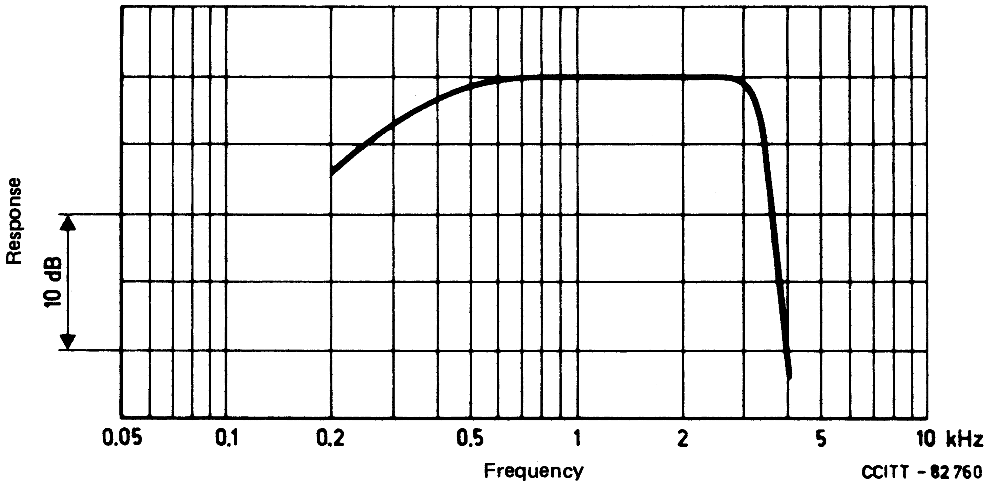


FIGURE 2

**Receiving frequency response according to [2]**

## 3 Receiving sensitivity

Receiving sensitivity today often is represented by values between an RLR of –4 dB and –12 dB respectively.

A further increase of the sensitivity by the use of amplifiers might technically be possible. However, the probability for the audibility of crosstalk will increase with increased sensitivity. Therefore, the information gathered in Recommendation P.16 must be considered and it is doubtful if it can be recommended to increase the sensitivity further beyond an RLR of –12 dB.

Increasing the receiving sensitivity also decreases the margins against the effects of speech-off noise on the connection, e.g. unwanted modulation products from PCM systems. The stability against singing will also be affected.

## 4 Sending frequency response

Having chosen the receiving response to be flat, the sending frequency response can be optimized to give the proper overall characteristic. Reference [3] suggests an optimization achieved by asking the listeners for the "preferred" response. The result is shown in Figure 3. Reference [4] suggests a 2 to 3 dB increase per octave with increasing frequency. This result was obtained in tests regarding "naturalness". Reference [2] suggests a steeper curve (Figure 4) as a result of an optimization where maximum loudness, minimum listening effort and lowest output level are combined. The degree of freedom used by [2] is of course less than in [3] and [4]. Here we may have a difference in opinion concerning which assumptions we must include in the optimization. If the signal-to-noise ratio is a problem, some decibels could be gained (without overloading) in the way shown by [2]. If there are no signal-to-noise ratio problems, an optimization for best naturalness as in [3] and [4] can be used. Thus, the result will depend on the assumptions.

Different opinions may also exist about the local cable length for which the frequency response should be optimized and if the high frequency loss at long lines should be compensated. Reference [2] suggests optimization of the mean local line which will be optimum to the highest number of subscribers (because of the statistical distribution of cable lengths).

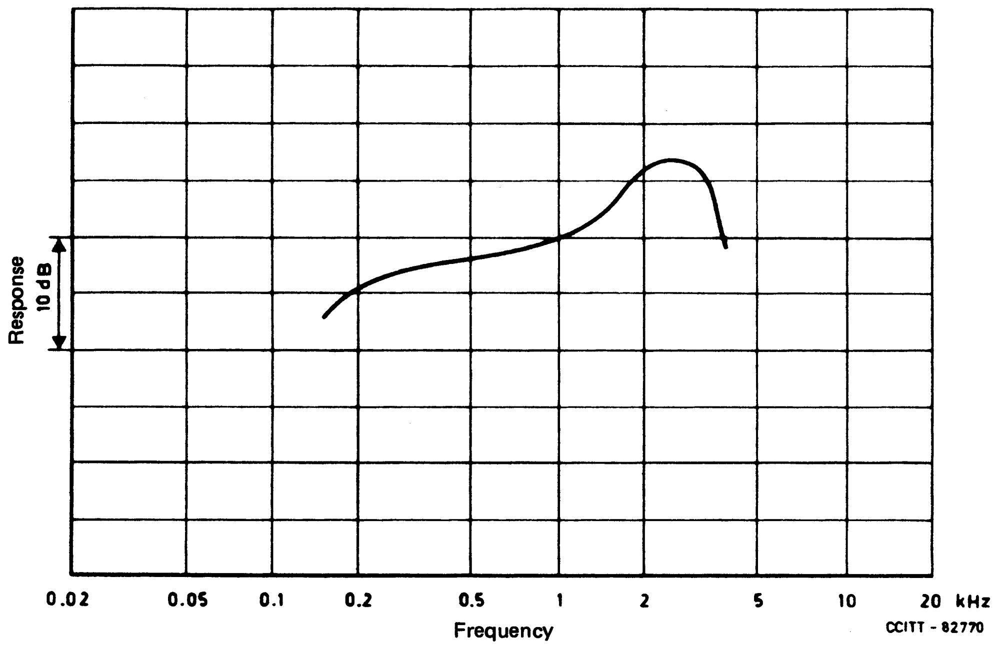


FIGURE 3

**Sending frequency response according to [3]**

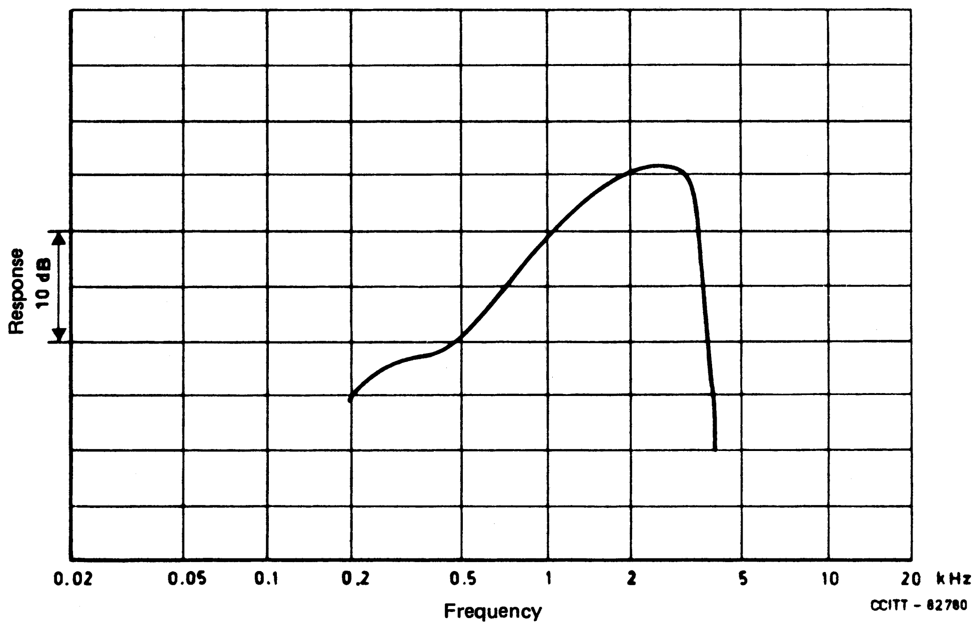


FIGURE 4

**Sending frequency response according to [2]**

The curves according to Figure 4 and [4] give with a flat receiving frequency response an overall characteristic close to what is obtained by the diffraction effect at free-field listening. However, this is probably not the whole explanation to the preferred curves. Even if the receiving responses were flat during sealed measuring conditions, hardly anyone keeps the earphone tight to the ear during conversation. Therefore, the actual responses during conversation probably give some additional low frequency cut-off that certainly has an influence on the results (see also reference [5]).

## 5 Sending sensitivity

When we want to choose the sending sensitivity we have one degree of freedom less that at the receiving end. We must consider both the probability of crosstalk and the probability of overloading other parts of the telephone system. Actual output levels from the telephone must be considered. As shown in [6] different output levels for the same SRE-value have been found in different countries. However, the different results show one important feature in common: output levels during normal conversation are generally lower than during reference equivalent measurements. Hopefully we will get better agreement on this point in the future if we use the measuring distance defined in Recommendation P.76, Annex A for loudness rating measurements.

## 6 Regulation

A possibility to increase the sending sensitivity on long lines exists if we use sending regulation dependent on line length. The probability for overloading and the probability for far end crosstalk will not increase if the mean power is kept to the same value as today. See also [2]. The probability of near end crosstalk in the local cable will of course increase and has to be considered.

If regulation is introduced both at sending and receiving, more subscribers may experience an overall loudness rating close to a preferred optimum, i.e. less calls will be rated poor and unsatisfactory. Another reason to introduce regulation is to obtain a better sidetone performance on short and long lines at the same time.

## 7 Impedance presented to the line

Some considerations concerning this topic are as follows:

– a conjugate match with the line maximizes the power transferred but creates sidetone problems on short lines and also stability/echo problems on long-distance calls;

– an image match to the line reduces the range of impedance presented to the exchange and eases the sidetone problem except for short subscriber-lines connected to resistive junction plant (e.g. PCM circuits);

– an impedance approximating the reference resistance (e.g. 600 ohms) eases standardization problems particularly in respect of alternative uses of the local line for non-speech services, but the optimum in respect of sidetone cannot be attained over the whole range of local line lengths.

References [2], [7] and [11] touch upon this subject.

## 8 Sidetone balance impedance

The degree of sidetone suppression is governed by the following parameters:

– microphone sensitivity;

– earphone sensitivity;

– sidetone balancing arrangement within the telephone instrument circuit;

– the impedance of the line to which the telephone is connected.

The microphone and earphone sensitivities and the instrument circuit are in part controlled by the required sending and receiving sensitivities. The impedance of the line to which the telephone is connected is not usually within the control of the telephone instrument designer. The only parameter freely available to the telephone designer to control the sidetone level is $Z_{SO}$, the sidetone balance impedance [7], [8], the impedance which when connected to the telephone completely suppresses sidetone (see also ref. [12]). If a transformer hybrid is used in the telephone then the internal balance network impedance is equal to the sidetone-balance impedance $Z_{SO}$ modified by the turns ratio of the transformer. However, the concept $Z_{SO}$ is not affected if the circuit uses any other form of balancing arrangement instead of a transformer.

## 9 Interworking with the existing network

The design of new handset telephones to be introduced into the telephone network must take account of the need to give satisfactory transmission on connections to existing local telephone circuits either directly or via the long-distance network. Reference [7] contains information touching upon this aspect.

Reference [10] is an example of a specification used in North America. Guidance for desirable sending and receiving levels are given as well as characteristics to be minimally acceptable for connection to the public switched network. It should be noted that this specification uses IEEE terminology, which is different from that found in CCITT Recommendations.

## References


[1] CCITT Recommendation *Description of the ARAEN*, Green Book, Vol. V, Rec. P.41, Fig. 4, ITU, Geneva, 1972.

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[8] RICHARDS (D. L.): Telecommunications by speech, Chapter 5, *Butterworths*, London, 1973.

[9] CCITT Contribution COM XII-No. 105 (LME), Study Period 1973-1976.

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[12] CCITT Handbook on *Telephonometry*, Geneva, 1987.

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