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SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

International telephone connections and circuits – General characteristics of the 4-wire chain formed by the international circuits and national extension circuits

Talker echo and its control

ITU-T Recommendation G.131

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
General definitions	G.100–G.109
General Recommendations on the transmission quality for an entire international telephone connection	G.110–G.119
General characteristics of national systems forming part of international connections	G.120–G.129
General characteristics of the 4-wire chain formed by the international circuits and national extension circuits	**G.130–G.139**
General characteristics of the 4-wire chain of international circuits; international transit	G.140–G.149
General characteristics of international telephone circuits and national extension circuits	G.150–G.159
Apparatus associated with long-distance telephone circuits	G.160–G.169
Transmission plan aspects of special circuits and connections using the international telephone connection network	G.170–G.179
Protection and restoration of transmission systems	G.180–G.189
Software tools for transmission systems	G.190–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TESTING EQUIPMENTS	G.500–G.599
TRANSMISSION MEDIA CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DIGITAL TERMINAL EQUIPMENTS	G.7000–G.7999
DIGITAL NETWORKS	G.8000–G.8999

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation G.131

Talker echo and its control

Summary

This Recommendation provides guidance on the effect of talker echo and its control. Talker echo is considered independently of all other impairments. Furthermore, the conjunction of talker echo and the E-model of ITU-T Rec. G.107 is explained as well as the reference to ITU-T Rec. G.108.2 on transmission planning aspects of echo cancellers is provided.

Previous versions of this Recommendation included a clause on stability that has been deleted because modern networks are largely all four-wire.

Earlier versions of this Recommendation contained several planning rules for connections with echo control devices. As many of those rules are now obsolete, they are not reproduced here.

A new Appendix III on the Combined effects of talker echo in the presence of absolute delay has been added.

Source

ITU-T Recommendation G.131 was approved by ITU-T Study Group 12 (2001-2004) under the ITU-T Recommendation A.8 procedure on 13 November 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. 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 Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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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As of the date of approval of this Recommendation, 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

		Page
1	Introduction	1
2	References	1
3	Effect of talker echo	2
4	Effect of talker echo on overall speech transmission quality	4
5	Active echo control devices	5
6	Rules for connections with echo control devices	5
Appendix I – Assessment of talker echo effects		6
Appendix II – Relation between echo disturbances under single talk and double talk conditions (evaluated for one-way transmission time of 100 ms)		7
II.1	Introduction	7
II.2	Echo assessment for the test conditions according to ITU-T Rec. G.131	8
II.3	Correlation between the results under single and double talk conditions	9
Appendix III – Combined effects of talker echo in the presence of absolute delay		10

ITU-T Recommendation G.131

Talker echo and its control

1 Introduction

This Recommendation provides guidance on the effect of talker echo, and some general rules for the insertion of network echo cancellers. (Talker echo is considered independently of all other impairments.)

In a telephone conversation a talker sometimes can hear his own voice as a delayed echo.

This phenomenon is referred to as talker echo; it is caused by signal reflections in the transmission path; such can either be caused by 4-wire/2-wire hybrids, or by an acoustic feedback via the airpath at the listener side, i.e. from the earpiece (or loudspeaker) to the microphone; other causes include crosstalk in the handset cord.

In cases where the reflected voice signal has a delay close to zero it is referred to as sidetone, see ITU-T Rec. G.121 [7].

NOTE – Previous versions of this Recommendation included a clause on stability that has been deleted because modern networks are largely all four-wire.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[1] ITU-T Recommendation G.100 (2001), *Definitions used in Recommendations on general characteristics of international telephone connections and circuits*.

[2] ITU-T Recommendation G.107 (2003), *The E-model, a computational model for use in transmission planning*.

[3] ITU-T Recommendation G.108 (1999), *Application of the E-model: A planning guide*.

[4] ITU-T Recommendation G.108.2 (2003), *Transmission planning aspects of echo cancellers*.

[5] ITU-T Recommendation G.109 (1999), *Definition of categories of speech transmission quality*.

[6] ITU-T Recommendation G.114 (2003), *One-way transmission time*.

[7] ITU-T Recommendation G.121 (1993), *Loudness ratings (LRs) of national systems*.

[8] ITU-T Recommendation G.122 (1993), *Influence of national systems on stability and talker echo in international connections*.

[9] ITU-T Recommendation G.164 (1988), *Echo suppressors*.

[10] ITU-T Recommendation G.165 (1993), *Echo cancellers*.

[11] ITU-T Recommendation G.168 (2002), *Digital network echo cancellers*.

[12] ITU-T Recommendation P.310 (2003), *Transmission characteristics for telephone band (300-3400 Hz) digital telephones*.

[13] ITU-T Recommendation Q.115.1 (2002), *Logic for the control of echo control devices and functions*.

3 Effect of talker echo

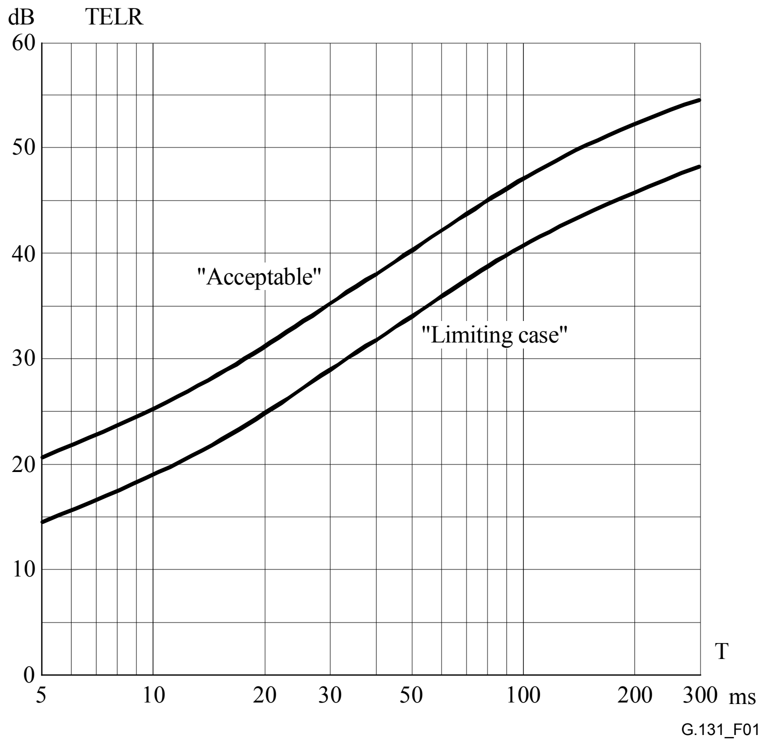
The degree of annoyance of talker echo depends both on the amount of delay and on the level difference between the original voice and the received echo signal. This level difference is characterized by the measure "Talker Echo Loudness Rating" (TELR).

ITU-T Rec. G.122 [8] describes how TELR can be determined from the Echo Loss (EL) of a 4-wire/2-wire hybrid and from the weighted Terminal Coupling Loss (TCLw) of a telephone set respectively.

Recommended limits for TCLw of telephone sets can be found in the P.300-series of Recommendations; e.g., ITU-T Rec. P.310 [12] provides specifications for limits of acoustic feedback for standard digital telephone sets.

Furthermore, delay estimations for various connection elements are given in ITU-T Rec. G.114 [6].

Figure 1 shows the minimum requirements on TELR as a function of the mean one-way transmission time T (half the value of the total round-trip delay from the talker's mouth to the talker's ear). In general, the "acceptable" curve is the one to follow. Only in exceptional circumstances should values for the "limiting case" be allowed.



T Mean one-way transmission time
TELR Talker Echo Loudness Rating

Figure 1/G.131 – Talker echo tolerance curves

Previous versions of this figure (see Figure 2/G.131 (1988)) included curves labelled "1%" and "10%", which sometimes caused confusion as to what these terms meant; these percentages refer to the probability of encountering objectionable echo. Transmission planning experience, corroborated by computational modelling results, has shown that the earlier "1%" curve for all-digital networks corresponds to the limit for acceptable talker echo performance (with some margins), so it is retained and labelled "Acceptable". The "limiting case" curve corresponds to a TELR of 6 dB lower (than that of the new acceptable curve) and should only be used in exceptional circumstances, as it corresponds to a 10% probability of encountering objectionable echo.

It must be mentioned that the Transmission Rating Model of ITU-T Rec. G.107 [2] (the E-model) takes into account the effect of echo on speech transmission quality based on these graphs. Thus, if the E-model is used considering the effects of talker echo only (i.e., with nominal values for all other parameters) the upper graph, labelled "Acceptable", corresponds to an E-model Rating of $R = 74$, whereas the lower graph, labelled "Limiting case", corresponds to $R = 60$.

Figures 2a and 2b provide the requirements for talker echo derived from the E-model. The dashed graphs in Figures 2a and 2b are representing $R = 74$ and $R = 60$.

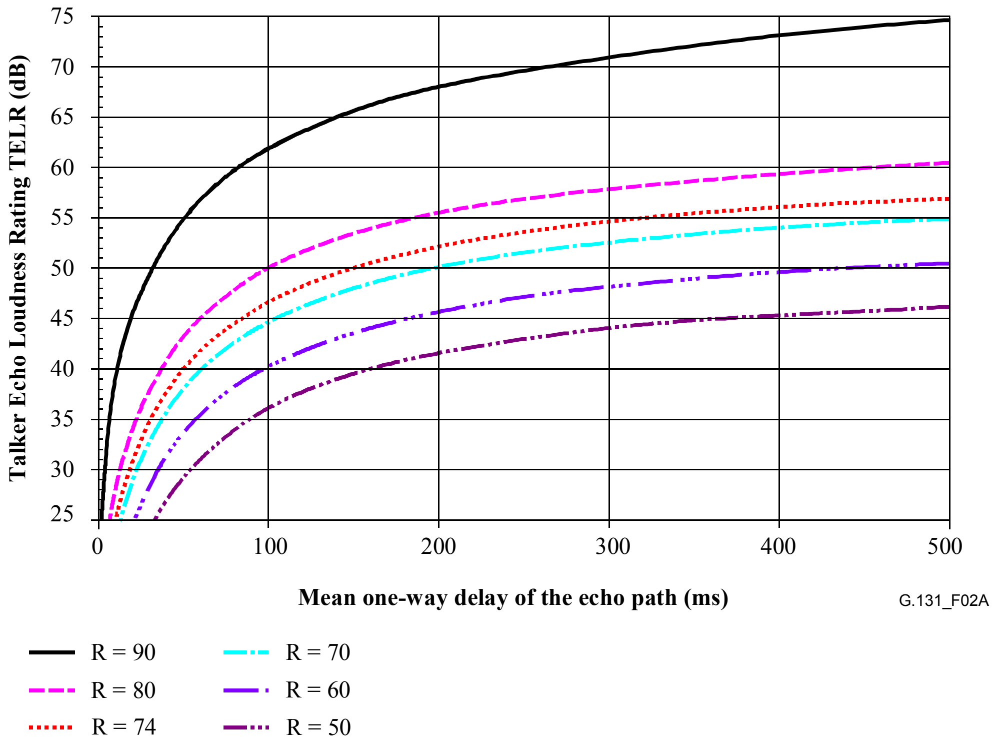


Figure 2a/G.131 – Effects of talker echo based on E-model

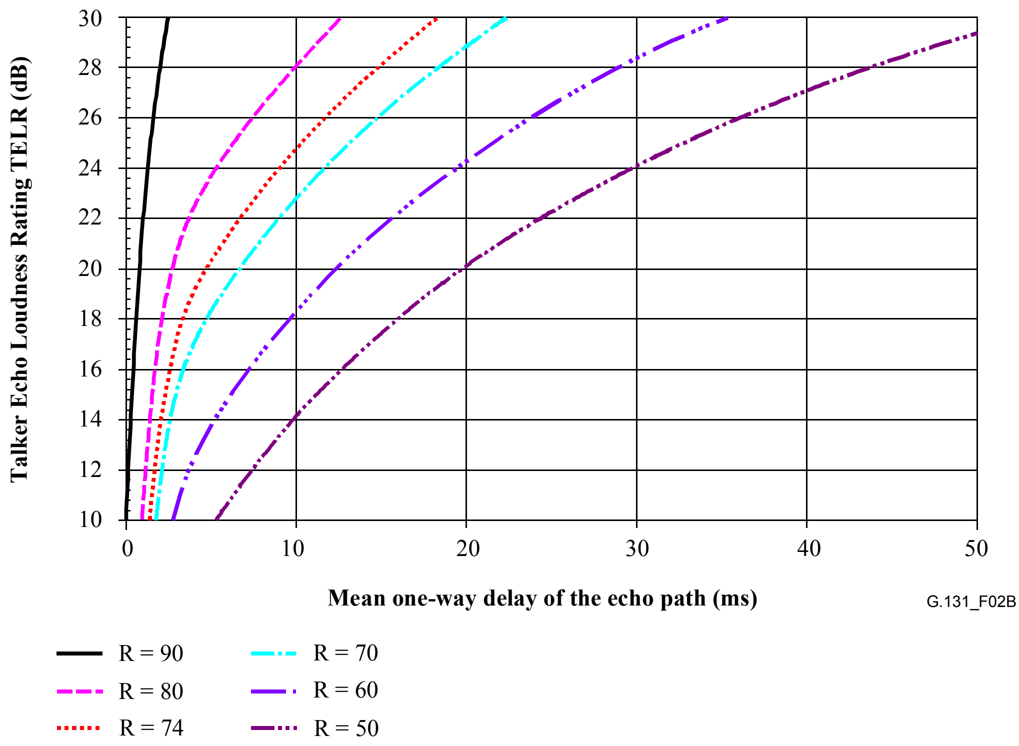


Figure 2b/G.131 – Effects of talker echo based on E-model

In order to use the curves of Figure 1 without using the whole E-model from ITU-T Rec. G.107 [2], the following rule, derived from formula 3-22/G.107, can be used:

– if x and y are respectively the values of the mean one-way transmission time and of the talker echo return loss (i.e., the coordinates of the corresponding plot on Figure 1) as evaluated for a given link or communication, then:

$$f(x, y) = y - 40 \log \left(\frac{1 + \frac{x}{10}}{1 + \frac{x}{150}} \right) + 6e^{-0.3x^2}$$

– if $f(x,y) \leq 8$ (i.e., below the "limiting case" curve), the echo will be annoying, and needs to be cancelled;

– if $8 < f(x,y) < 14$ (i.e., between both curves), the echo will be probably annoying;

– if $f(x,y) \geq 14$ (i.e., above the "acceptable" curve), the echo will not be annoying, and does not need to be cancelled.

4 Effect of talker echo on overall speech transmission quality

For general transmission planning purposes, the total effect of all transmission impairments may be estimated with the E-model of ITU-T Rec. G.107 [2]. For telephone connections incurring a higher amount of absolute end-to-end delay, it is very important to consider the combined effects of talker echo and absolute delay in order to cover both the single talk situation of either talker and the interactive situation between both parties involved in the call. For the convenience of the readers of this Recommendation, Appendix III provides a figure with respective graphs for tutorial purposes.

ITU-T Rec. G.108 [3] gives detailed examples on how to use the E-model to assess the transmission performance of connections involving various impairments, including talker echo; ITU-T Rec. G.109 [5] maps transmission rating predictions of the model into categories of speech transmission quality. Thus, while ITU-T Rec. G.131 provides useful information regarding talker echo as a parameter by itself, ITU-T Rec. G.107 [2] (and its ITU-T Recs G.108 [3] and G.109 [5] companions) should be used to assess the effects of talker echo in conjunction with other impairments (e.g., distortions due to speech processing).

5 Active echo control devices

For connections where the effects of talker echo are responsible for an undesirable decrease of transmission quality, the deployment of active echo control devices, such as echo cancellers, is a valid choice. Echo cancellers detect the echo portion contained in the receive signal of the talker and (attempt to) remove it from the receive signal; this is mainly based on a process of permanently estimating the echo path transfer function.

In former versions of this Recommendation, it was recommended that the active echo control devices be deployed on all connections which exceed the total one-way talker echo transmission path time of 25 ms. This guideline was intended to ensure the acceptable echo performance on international connections terminated by analogue subscriber lines.

However, echo control devices may be deployed in connections with less or more transmission time for reasons such that low or high values of TELR are to be expected in the network. In such cases, curves in Figure 1 can be used as the guidance for the desirable performance (see Appendix I). The threshold of 25 ms remains valid for networks using 600 Ω hybrids.

When TELR is much greater than 65 dB, the "no echo" curve from Appendix III may be applied.

For details on transmission planning aspects of echo cancellers, see ITU-T Rec. G.108.2 [4] and for details on echo canceller control logic, see ITU-T Rec. Q.115.1 [13].

In general it is recommended to only deploy echo cancellers into the network that conform to ITU-T Rec. G.168 [11]. Echo suppressors according to ITU-T Rec. G.164 [9] and echo cancellers according to ITU-T Rec. G.165 [10] may still be in use, but are not recommended for any new deployment.

A general rule for echo control devices is that they should ensure the returned echo from any device is less than –65 dBm0.

A trade-off between additional delay and talker echo is possible; see ITU-T Rec. G.108 [3] for planning examples and guidance also in this respect.

In some specific cases, such as interconnections between public and other networks (e.g., private networks), the public network may not provide sufficient echo control. In such cases, the need of providing echo control in the connection segment attached to the public network has to be considered by the private network provider.

6 Rules for connections with echo control devices

Earlier versions of this Recommendation contained several planning rules for connections with echo control devices. As many of those rules are now obsolete, they are not reproduced here. However, some rules still apply, for example:

1) Circuits with properly designed and thoroughly tested echo cancellers (meeting or exceeding the requirements of ITU-T Rec. G.168) can be connected in tandem without significant performance degradation.
2) Circuits with echo suppressors can be connected with circuits equipped with echo cancellers without additional performance degradation caused by the canceller; however, the overall performance will be limited by that provided by the poorer performing device.

Note that much new detail regarding the use of echo cancellers is provided in ITU-T Rec. G.108.2.

Appendix I

Assessment of talker echo effects

Figure I.1 illustrates the typical talker echo caused by a reflection at the 2-wire/4-wire hybrid at the far end of a connection.

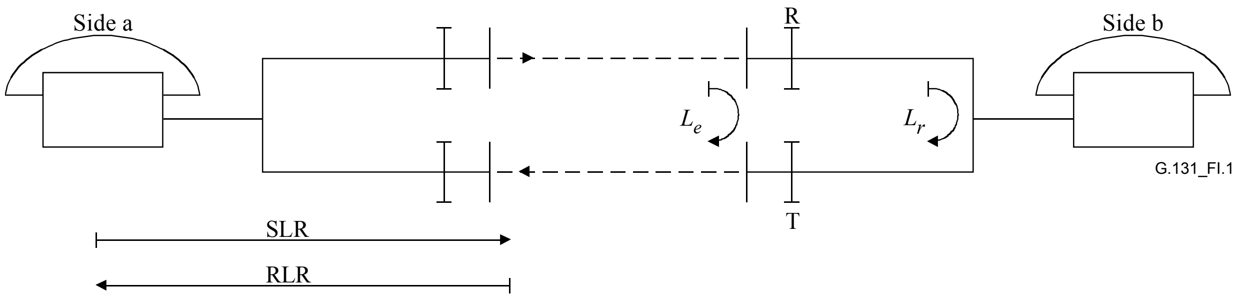


Figure I.1/G.131 – Talker echo at side a, caused by reflections at side b

With the designations of the figure:

$$TELR = SLR + RLR + L_e$$

and:

$$L_e = R + T + L_r$$

where L_r is the weighted average of the return loss at the hybrid, weighting according to ITU-T Rec. G.122 [8].

This Recommendation specifies that no special echo control devices are needed if T < 25 ms. According to Figure 1, this corresponds to TELR = 33 dB at the limit T = 25 ms. In many networks, (T + R) = 6 dB and $SLR_{nom} = 7$, $RLR_{nom} = 3$. Thus one should have $L_r > 17$ dB which is not unreasonable for an average length of subscriber cable and if the impedance of the terminals can be specified with fairly tight tolerances. However, this may not be the case for all networks as described in the examples below.

In some networks, the average return loss of the terminating impedances against a nominal balance impedance is 14 dB, with a standard deviation of 3 dB. Very short subscriber lines are also common. According to ITU-T Rec. G.121, the loudness ratings of the telephone sets are:

$$SLR_{nom} = 7,\ SLR_{min} = 2;\ RLR_{nom} = 3,\ RLR_{min} = 1$$

Example 1

Nominal loudness ratings, nominal return loss $L_r = 14$, zero length line.

$$TELR = 7 + 3 + 6 + 14 = 30$$

This corresponds to an "acceptable" limit T < 18 ms, "limiting case" T < 33 ms.

Example 2

Nominal loudness ratings, lowest "2-sigma" return loss $L_r = 8$ dB, zero line.

$$TELR = 7 + 3 + 6 + 8 = 24$$

This corresponds to an "acceptable" limit T < 9 ms, "limiting case" T < 19 ms.

Example 3

Loud telephone set, lowest "2-sigma" return loss L_r = 8 dB, zero line length.

$$\text{TELR} = 2 + 1 + 6 + 8 = 17$$

This corresponds to a "limiting case" of 7 ms.

Appendix II

Relation between echo disturbances under single talk and double talk conditions (evaluated for one-way transmission time of 100 ms)

II.1 Introduction

The telephone situation using a handset was reproduced in a third party listening test (LOT). The listening examples were generated by a computer simulation considering two double talk periods:

- sequence 1: a long double talk (a whole sentence); and
- sequence 2: a short double talk represented by a single word.

The structure of the listening examples can be subdivided into three periods:

- period A: listening to the far-end speech (male voice);
- period B: double talk period (sequence 1 or sequence 2, female voice);
- period C: listening again to the far-end speech.

In addition to the double talk conditions these two sequences were also judged under single talk conditions (no far-end speech was present). The test conditions were as follows:

- average speech level on both sides of the connection was adjusted to –4.7 dB_{Pa};
- simulated characteristics of a standard German handset (FEAP 7);
- the connection was simulated by different TELR values;
- TELRs representing the "acceptable curve" and "limiting case" were included;
- variable TELRs in combination with a one-way transmission time of 100 ms were included;
- 24 naive subjects were used as test persons;
- the parameters overall quality and echo were judged on a 5-point scale.

The different TELRs were adjusted by a digital attenuation in the (simulated) echo path. This does not influence the loudness of the far-end speech under double talk conditions. If variations of TELRs are simulated by a variable sensitivity in the sending direction of a far-end terminal, the loudness of far-end speech is affected too. Consequently, the masking effect during double talk would be lower and would influence the echo judgement. This influence was excluded.

II.2 Echo assessment for the test conditions according to ITU-T Rec. G.131

The results are given in Figures II.1 and II.2.

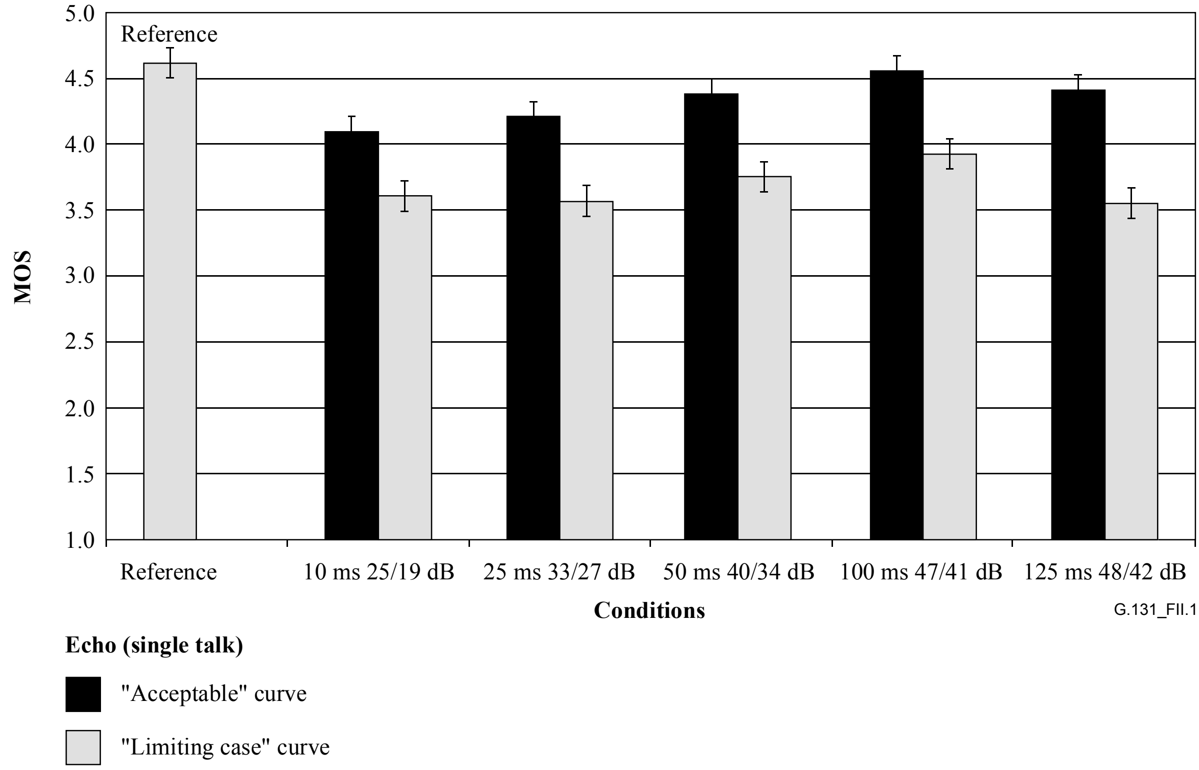


Figure II.1/G.131 – Results under single talk conditions

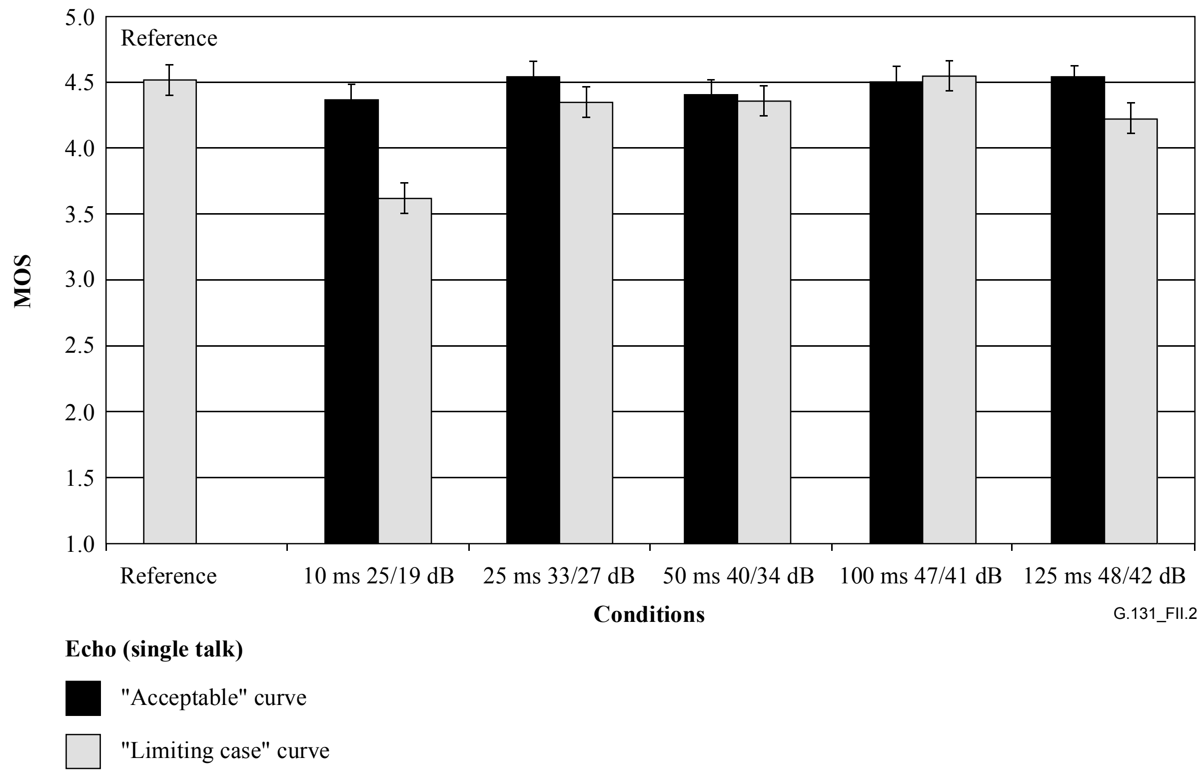


Figure II.2/G.131 – Results under double talk conditions

The ratings from Figures II.1 and II.2 are given again in Table II.1.

Table II.1/G.131 – Echo assessment in LOT

Conditions	MOS single talk	MOS double talk
Reference (infinite TELR)	4.62	4.60
"acceptable curve"	4.0-4.6	4.0-4.5
"limiting case"	3.5-4.0	4.0-4.5

II.3 Correlation between the results under single and double talk conditions

Variable TELRs in combination with a transmission time of 100 ms were judged under single and double talk conditions. The correlation between the MOS under both conditions is demonstrated graphically in Figure II.3 for the parameters' overall quality and echo. The echo level offset under double talk condition is given as a function of MOS under single talk condition. It indicates the possible echo level offset under double talk condition to still achieve the same rating compared to the single talk condition.

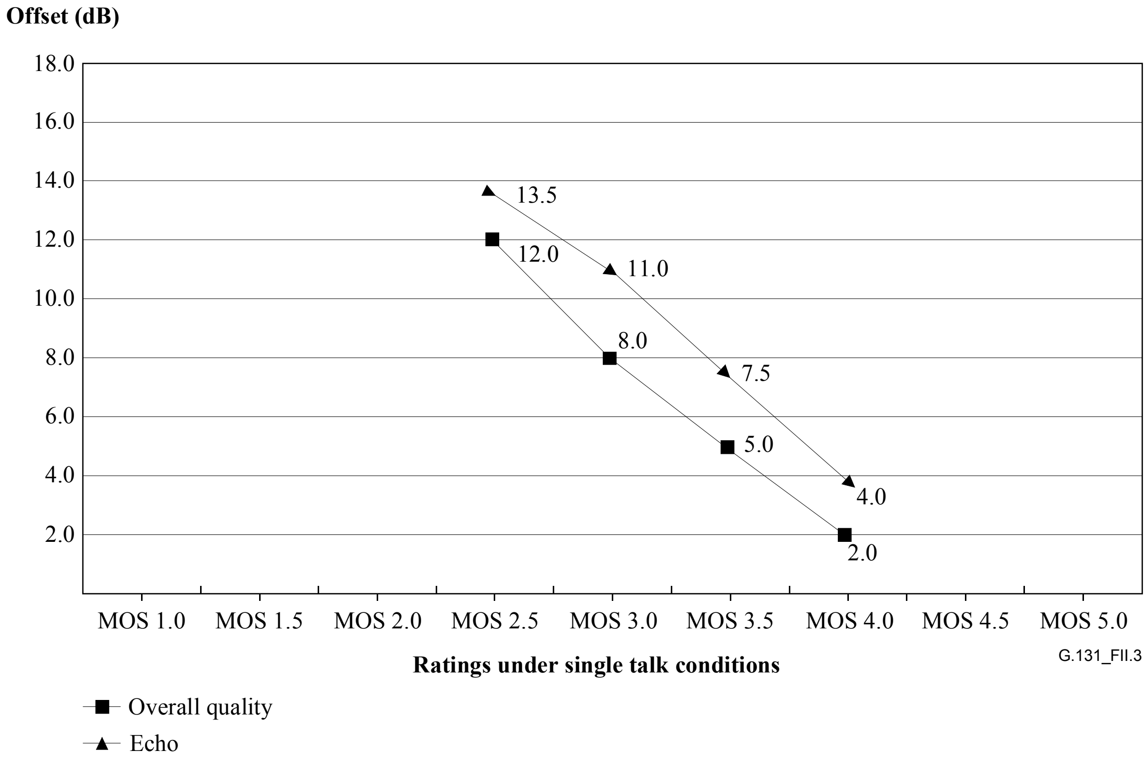


Figure II.3/G.131 – Echo level offset during double talk to achieve the same MOS values compared to the single talk condition (transmission time: 100 ms)

It can be assumed that a similar functional relation exists for other combinations of transmission time and TELR values although the exact curves might be slightly different.

Appendix III

Combined effects of talker echo in the presence of absolute delay

Figure III.1 provides an overview of the combined effects of talker echo in the presence of absolute delay. It has been derived from the E-model of ITU-T Rec. G.107 [2] (see ITU-T Rec. G.114 [6] for a similar exhibit).

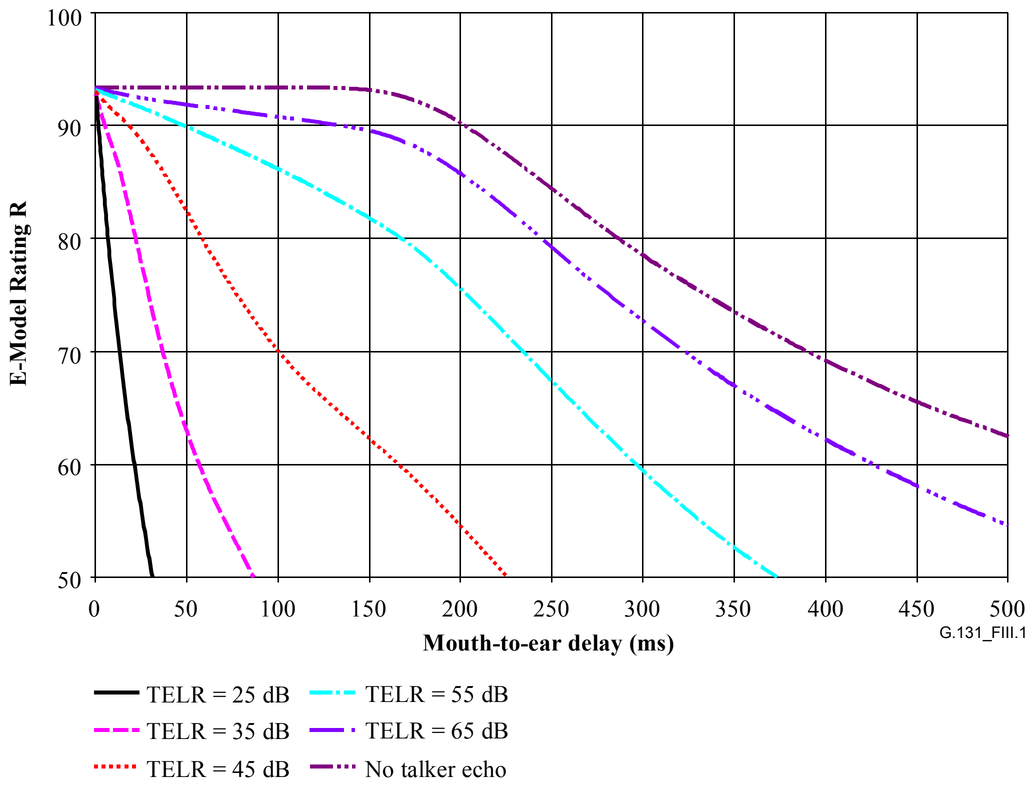


Figure III.1/G.131 – Combined effects of talker echo in the presence of absolute delay

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