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THE INTERNATIONAL
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CONSULTATIVE COMMITTEE

# G.131/Q.42

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

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

SERIES Q: SWITCHING AND SIGNALLING

International automatic and semi-automatic working – General characteristics for international telephone connections and circuits

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## STABILITY AND ECHO

Reedition of CCITT Recommendation G.131/Q.42
published in the Blue Book, Fascicle III.1 (1988)

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## NOTES

1 CCITT Recommendation G.131/Q.42 was published in Fascicle III.1 of the *Blue Book*. This file is an extract from the *Blue Book.* While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

**Recommendation G.131**

# STABILITY AND ECHO

*(Geneva, 1964; amended at Mar del Plata, 1968, and Geneva, 1972, 1976, and 1980; Malaga-Torremolinos, 1984 and Melbourne, 1988)*

## 1 Stability of telephone transmission

The nominal transmission loss of international circuits having been fixed, the principal remaining factors which affect the stability of telephone transmission on switched connections are:

– the variation of transmission loss with time and among circuits (Recommendation G.151, § 3);

– the attenuation distortion of the circuits (Recommendation G.151, § 1);

– the distribution of stability balance return losses (Recommendation G.122, §§ 2 and 3).

The stability of international connections has been calculated and the results are displayed graphically in Figure 1/G.131, which shows the proportion of connections (out of all the possible connections) likely to exhibit a stability of less than or equal to 0 dB or 3 dB as a function of the number of all analogue circuits comprising the 4-wire chain and the mean values of stability balance return loss that may be assumed. Of course the proportion of connections actually established which exhibit a stability lower than or equal to the values considered will be very much smaller.

*Note* – If digital circuits are included in the 4-wire chain, the stability is likely to be better than shown in Figure 1/G.131, as these circuits will exhibit a lower transmission loss variability than is assumed in that figure.

When interpreting the significance of the curves showing the proportion of calls likely to have a stability of 3 dB or less it should be borne in mind that the more complicated connections will undoubtedly incorporate a circuit equipped with an echo suppressor or canceller, in which case the stability during conversation is very much higher.

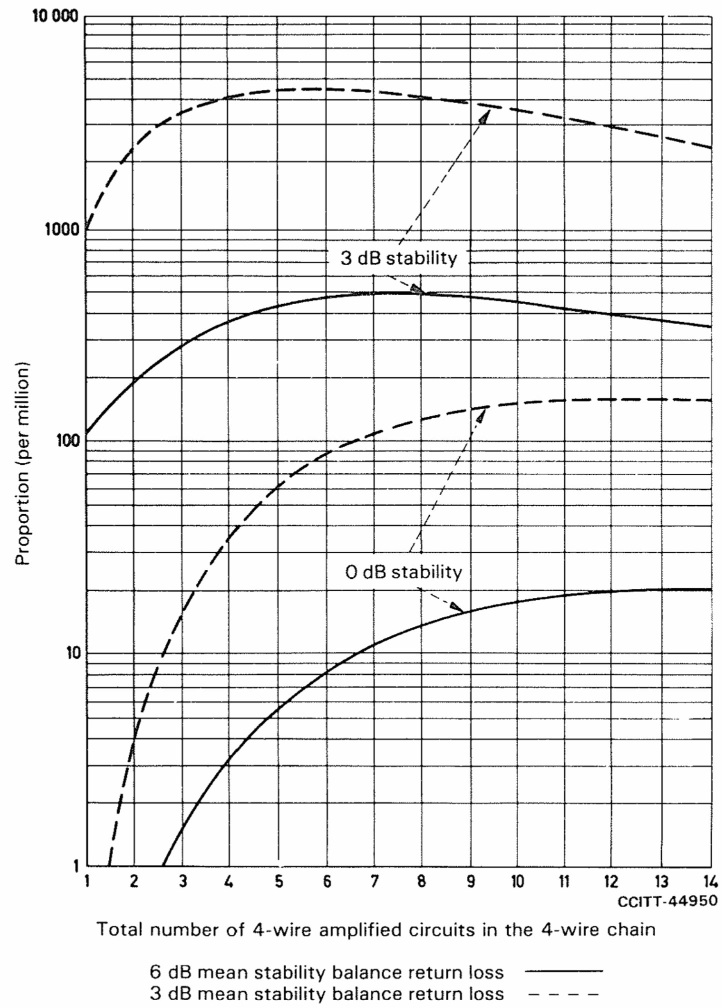



FIGURE 1/G.131

**Proportion of possible connections with a stability equal to or less than 0 dB or 3 dB**

The simplifying assumptions underlying the calculations are:

a) National circuits are added to the international chain in compliance with Recommendation G.122.

b) The standard deviation of transmission loss among analogue international circuits routed on groups equipped with automatic regulation is 1 dB. This accords with the assumptions used in Recommendation G.122. The results of the 10th series of tests by Study Group IV indicate that this target is being approached in that 1.1 dB was the standard deviation of the recorded data and the proportion of unregulated international groups in the international network is significantly decreasing.

c) The variations of transmission loss in the two directions of transmission are perfectly correlated.

d) The departure of the mean value of the transmission loss from the nominal value is zero. As yet there is little information concerning international circuits maintained between 4-wire points.

e) No allowance has been made for the variations and distortions introduced by the national and international exchanges.

f) The variation of transmission loss of circuits at frequencies other than the test frequency is the same as that at the test frequency.

g) No account has been taken of attenuation distortion. This is felt to be justifiable because low values of balance return loss occur at the edges of the transmitted band and are thus associated with higher values of transmission loss.

h) All distributions are Gaussian.

Bearing in mind these assumptions, the conclusion is that the Recommendations made by the CCITT are self-consistent and that if these Recommendations are observed and the maintenance standard set for variation of loss among circuits is achieved, there should be no instability problems in the transmission plan. It is also evident that those national networks which can exhibit no better stability balance return loss than 3 dB mean, 1.5 dB standard deviation are unlikely to seriously jeopardize the stability of international connections as far as oscillation is concerned. However, the near-singing distortion and echo effects that may result give no grounds for complacency in this matter.

Details of the calculations are set out in [1].

## 2 Limitation of echoes

The main circuits of a modern telephone network providing international communications are high-velocity carrier circuits on symmetric, coaxial or optical fibre pairs or radio-relay systems. Echo control devices such as echo suppressors and echo cancellers are not normally used except on connections involving very long international circuits. There is often no general need for echo control devices in national networks but they may be required for the inland service in large countries. Echo control devices may also be needed on loaded-cable circuits (low-velocity circuits) used for international calls.

Echoes may be controlled in one of two ways: either the overall loss of the 4-wire chain of circuits may be adjusted so that echo currents are sufficiently attenuated (which tacitly assumes a particular value for the echo return loss) or an echo control device can be fitted.

### 2.1 *Transmission loss adjustment*

The curves of Figure 2/G.131 indicate the minimum value of the overall loudness rating (OLR)[1] in the echo path that must be introduced if no echo suppressor is to be fitted. The OLR is shown as a function of the mean one-way propagation time. Supplement No. 2, at the end of this fascicle, explains how these curves have been derived and Annex A to this Recommendation gives an example of their application.

The solid curves are applicable to a chain of analogue circuits which are connected together 4-wire. However, they may also be used for circuits connected together 2-wire if precautions have been taken to ensure good echo return losses at these points (i.e. averaged in accordance with Recommendation G.122) for example, a mean value of 27 dB with a standard deviation of 3 dB.

*Note* – This value is only sufficient to assure average echo losses (*a*-*b*) of (15 + *n*) dB, as currently called for in Recommendation G.122 § 4.1.

The dashed curve is applicable to fully digital connections with analogue subscriber lines (such as shown in Figure 2/G.111), and, under certain assumptions (see Supplement No. 2), to fully digital connections with digital

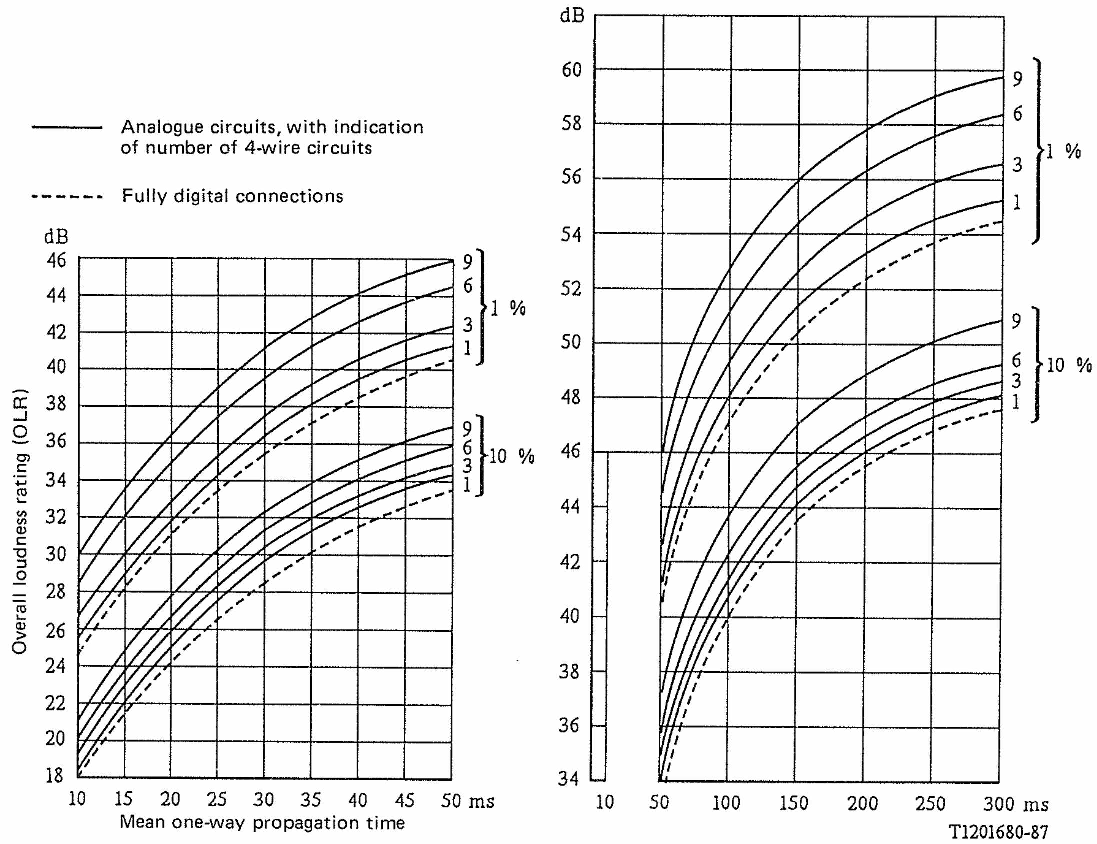
[1] While Figure 2/G.131 is based on nominal values of LR of trunk junction and trunk circuits, it refers to minimum SLR and RLR values of subscriber systems.

subscriber lines (such as shown in *b)* of Figure 1/G.104. In the latter case the echo path includes the acoustical path between earpiece and mouthpiece of the handset.

When an international circuit is used only for comparatively short and straightforward international connections the nominal transmission loss between virtual analogue switching points may be increased in proportion to the length of the circuit according to the following rule, if the use of echo control devices can thereby be avoided:

- up to 500 km route distance: 0.5 dB;
- between 500 km and 1000 km route distance: 1.0 dB;
- for every additional 500 km or part thereof: 0.5 dB.

However, such a circuit may not form part of multicircuit connections unless the nominal transmission loss is restored to 0.5 dB.




*Note 1* – The percentages refer to the probability of encountering objectionable echo.

*Note 2* – The overall loudness rating of the echo path is here defined as the sum of:

- the loudness rating in the two directions of transmission of the local telephone system of the talking subscriber (assumed to have minimum values of loudness rating);
- the loudness rating in the two directions of transmission of the chain of circuits between the 2-wire end of the local telephone system of the talking subscriber and the 2-wire terminals of the 4 wire-2 wire terminating set at the listener's end;
- the mean value of the echo balance return loss at the listener's end.

FIGURE 2/G.131

**Echo tolerance curves**

## 2.2 *Echo control devices*

The preferred type of echo suppressor is a terminal, differential, half-echo suppressor operated from the far end. There are several types of half-echo suppressor in use in the international network, one suitable only for use in connections with mean one-way propagation times not exceeding 50 ms, referred to as a short-delay echo suppressor, and the others suitable for use in connections with any mean one-way propagation time, especially times well over 50 ms, referred to as a long-delay echo suppressor like those used on circuits routed on communication-satellite systems. The characteristics of the short-delay echo suppressors are given in [2]. The characteristics of echo suppressors which can be used on connections with either short or long propagation times are given in [3] and in Recommendation G.164

(echo suppressors with new functions). Another type of echo control can be obtained by echo cancellers. The characteristics are given in Recommendation G.165.

From subjective test information received, it is concluded that:

1) Echo cancellers in accordance with Recommendation G.165 provide superior speech transmission performance (at the 0.05 confidence level) to that provided by:

   a) echo suppressors according to Recommendation G.161 (*Orange Book*);

   b) echo suppressors according to Recommendation G.164 with fixed break-in differential sensitivity, FBDS;

   *Note* – Two Administrations have the view that echo cancellers according to Recommendation G.165 and echo suppressors according to Recommendation G.164 with adaptative break-in differential sensitivity (ABDS) provide about the same performance when the echo path loss is considerably above the lower end of its range; calculations based on Recommendation G.122, § 2 and assuming a minimum echo loss of 6 dB, indicate that the majority of echo path losses will be greater than the minimum value.

2) echo suppressors in accordance with Recommendation G.164 with ABDS provide superior speech transmission performance to that provided by echo suppressors with FBDS.

3) echo control devices of different types (i.e. echo suppressors or cancellers in accordance with the series G Recommendations) placed at opposite ends of a connection will operate compatibly. In this case the subjective quality perceived at one end is almost uniquely dependent on the performance of the echo control device installed at the opposite end.

*Note 1* – Regional satellite circuits routed in parallel with terrestrial circuits, without perceivable echo, will benefit from the use of echo control devices of the best quality. Otherwise any degradation of the normal quality by routing over the satellite circuit may be found objectionable by the subscriber.

*Note 2* – Bilateral agreement between Administrations may facilitate the introduction in the network of echo control devices of better quality.

### 2.3 *Rules governing the limitation of echoes*

The rules given below are subdivided into ideal rules and practical rules. It is recognized that no practical solution to the problem could comply with rules so exclusive and inflexible as the ideal rules. Practical rules are suggested in the hope that they will ease the switching and economic problems. They should not be invoked unless the ideal rules cannot reasonably be complied with.

#### 2.3.1 *Rules for connections without echo control devices*[2]

##### 2.3.1.1 *Ideal rule – Rule A*

For a connection between any pair of local exchanges in different countries, the probability of incurring the opinion "unsatisfactory" due to talker echo shall be less than 1%, when minimum practical nominal send and receive loudness ratings are assumed for the talker's telephone and line.

*Note* – Calls between a given pair of local exchanges may encounter different numbers of 4-wire circuits, according to the routing discipline and time of day. Figure 2/G.131 permits compliance with this rule to be assessed for the separate parts of the total traffic which encounter 1, 2, 3 . . . 9 4-wire circuits, under certain conventional assumptions. (See Supplement No. 2 at the end of this fascicle.)

##### 2.3.1.2 *Practical rule – Rule E*

For connections involving the longest national 4-wire extensions of the two countries, a probability of incurring an "unsatisfactory" opinion due to echo not of 1% (Rule A) but of 10% can, by agreement between the Administrations concerned, be tolerated. This Rule E[3] is valid only in those cases where it would otherwise be necessary, according to Rule A, to use an echo control device solely for these connections, and where there is no need

[2] The rules in this Recommendation have been updated (to include echo cancellers) and regrouped, compared with previous versions of Recommendation G.131. The letters indicating the rules are the same as in previous versions of Recommendation G.131 in order to provide a degree of continuity.

[3] Recommendation Q.115 [4] is a study of the application of Rules A and E to the United Kingdom-European network relations

for echo control devices on connections between the regions in the immediate neighbourhood of the two international centres concerned.

2.3.2 *Rules for connections with echo control devices*

2.3.2.1 *Ideal rules*

2.3.2.1.1 *Rule B*

1) Not more than the equivalent of one full echo suppressor (i.e. two half-echo suppressors) should be included in any connection needing an echo suppressor. When there is more than one full echo suppressor the conversation is liable to be clipped; lockout can also occur.

2) Circuits equipped with echo cancellers (Recommendation G.165) can be connected together in tandem without echo performance degradation.

3) A circuit equipped with echo suppressors (Recommendation G.164) can be connected with another circuit equipped with echo cancellers (Recommendation G.165) without additional performance degradation.

*Note* – The overall performance will not be better than that provided by the poorer performing device.

2.3.2.1.2 *Rule D*

The half-echo suppressors should be associated with the terminating sets of the 4-wire chain of the complete connection. This:

– reduces the chance of speech being multilated by the echo suppressors because the hangover times can be very short;

– reduces the change of ineffective echo canceller operation as end delays are short and minimum required echo losses can be assured.

2.3.2.2 *Practical rules*

2.3.2.2.1 *Rule F*

If, as is appreciated, Rule D above cannot be complied with, the echo control device may be fitted at the international exchange or at an appropriate national transit centre. However, each echo control device should be located sufficiently near to the respective subscribers for the end delays not to exceed the maximum value recommended in Recommendation G.161, (*Orange Book*) and Recommendations G.164 and G.165 of this fascicle. For countries of average size, this will normally mean that the originating and terminating control devices will be in the countries of origin and destination of the call.

2.3.2.2.2 *Rule G*

In isolated cases a full short-delay echo suppressor may be fitted at the outgoing end of a transit circuit (instead of two half-echo suppressors at the terminal centres) provided that neither of the two hangover times exceeds 70 ms. This relaxation may reduce the number of echo suppressors required and may also simplify the signalling and switching arrangements. It is emphasized that full echo suppressors must not be used indiscriminately; the preferred arrangement is two half-echo suppressors as near the terminating sets as possible. A full echo suppressor should be as near to the "time-centre" of the connection as possible, because this will require lower hangover times.

Whether a full long-delay echo suppressor or canceller can be used in this circumstance is under study.

2.3.2.2.3 *Rule K*

On a connection that requires an echo suppressor, up to the equivalent of two full echo suppressors (e.g. three half-echo suppressors or two half-echo suppressors and a full one) may be permitted. Every effort should be made to avoid appealing to this relaxation because the equivalent of two or more full echo suppressors, with long hangover times, on a connection can cause severe clipping of the conversation and considerably increases the risk of lockout. This rule does not apply to echo cancellers (see Rule B).

2.3.2.2.4 *Rule L*

In general it will not be desirable to switch out (or disable) the intermediate echo suppressors when a circuit equipped with long-delay echo control devices is connected to one with short-delay echo suppressors. However, it would be desirable to switch out (or disable) the intermediate echo suppressors if the mean one-way propagation time of that portion of the connection which would now fall between the terminal half-echo suppressors is not greater than 50 ms, since the different types are likely to be compatible. An intermediate echo canceller need not be switched out.

2.3.3 *General rules*

2.3.3.1 *Ideal rule – Rule C*

Connections that do not require echo control devices should not be fitted with them, because they increase the fault rate and are an additional maintenance burden.

2.3.3.2 *Practical rules*

2.3.3.2.1 *Rule H*

In exceptional circumstances, such as breakdown, an emergency route may be provided. The circuits of this route need not be fitted with echo control devices if they are usable without them for a short period. However, if the emergency routing is to last more than a few hours, echo control devices must be fitted according to Rules A to E above.

2.3.3.2.2 *Rule J*

It is accepted that a connection that does not require an echo control devices may in fact be unnecessarily equipped with one or two half-echo suppressors, or a full echo suppressor or echo cancellers. (The presence of an echo suppressor in good adjustment on a circuit with modest delay times can hardly be detected and in the case of echo cancellers it may improve the overall performance of the connection.)

Where a terminating international exchange is accessible from an originating international exchange by more than one route, and

1) at least one route requires echo suppressors, and at least one route does not; and

2) the originating exchange is unable to determine which route is to be used;

echo control devices should be connected in all cases.

2.3.3.2.3 *Rule M*

It has been found in actual practice that echo can be made tolerable by providing loss in the circuit if the one-way propagation time (delay) of the echo is less than about 25 ms. For delays longer than this, too much circuit loss is needed to attenuate echo, and echo control devices are required.

*Note* – The equivalent of this rule is stated in Recommendation G.161, § B.b. (*Orange Book*). This rule has not been expressed in earlier versions of Recommendation G.131.

2.4 *Insertion of echo control devices in a connection*

Ways of inserting echo control devices in a connection which have been considered are the following:

1) provide a pool of echo control devices common to several groups of circuits, and arrange for an echo control device to be associated with any circuit that requires one (see Recommendation Q.115 [4]);

2) arrange for the circuits to be permanently equipped with echo control devices but switch them out (or disable them) when they are not required (see [5]);

3) divide the circuits of an international route into two groups, one with and one without echo control devices and route the connection over a circuit selected from the appropriate group according to whether the connection merits an echo control device. However, it is recognized that circuits may not be used efficiently when they are divided into separate groups. This must be borne in mind;

4) conceive schemes in which the originating country and the terminal country are divided into zones at increasing mean radial distances from the international centre and determine the nominal lengths of the national extensions by examining routing digits and circuits-of-origin.

Whichever method is used, due regard must be paid to the last sentence of § 2.1 above. Methods of achieving the required reduction of circuit losses are under study by the CCITT. The nature and volume of the traffic carried by a particular connection will also influence the economics of the methods and hence the choice among them.

The CCITT is currently studying what recommendations are necessary to ensure that the insertion of echo control devices in international connections complies, overall, with the practical rules given above.

It should be appreciated that different continents need not use the same method although the methods must be compatible to permit intercontinental connections. There appears to be no great difficulty in arranging this.

2.5 *Speech processing devices*

Some speech processing devices, such as speech interpolation devices, have an inherent echo-suppressor function. However, such devices may only suppress echo during the single talk mode and not during double talking conditions (see Recommendation G.164, § 1.7) unless they are equipped to perform full echo-suppressor functions. When devices without full echo control are connected in tandem with echo cancellers, performance degradation due to echo may occur during double talking conditions as the intermediate echo canceller will not be effective during double talk.

ANNEX A

(to Recommendation G.131)

**Application of Recommendation G.131, § 2**

Recommendation G.131, § 2.3.1.1, Rule A, requires, for each pair of countries, an assessment of echo conditions for each possible pair of local exchanges to ascertain whether the plot of corrected reference equivalent of echo path against mean one-way propagation time for that pair of exchanges, lies above or below the appropriate 1% line in Figure 2/G.131.

The variables in the problem are indicated in Table A-1/G.131 and illustrated for all analogue connections in Figure A-1/G.131 and for all digital connections in Figure A-2/G.131.

For a given pair of exchanges, all eight items are known or can be estimated. A plot of overall loudness rating [1) + 2) + 3) + 4) of Table A-1/G.131] as a function of mean one-way propagation time [5) + 6) + 7) of Table A-1/G.131] on Figure 2/G.131 may be assessed in relation to the 1% curve, for a given number of analogue circuits in the 4-wire chain for fully analogue connections and mixed analogue/digital connections or, for fully digital connections using the appropriate curve.

TABLE A-1/G.131

**Quantities needed for echo assessment**

| |
|---|
| *Overall loudness rating of the echo path, made up of the sum of:* |
| 1) the minimum of the sum of the values of the sending and receiving loudness ratings of the local system of country A (talker end)); |
| 2) the nominal loudness rating from, and to, the virtual analogue switching points ($a_A$ and $b_A$) of the chain of national circuits in country A, connecting the local exchange to the international exchange; |
| 3) the nominal loudness rating in each direction of transmission of the international chain; |
| 4) the echo loss ($a_B$-$b_B$) of the national system of country B (listener end). |
| *Mean one-way propagation time, made up of half the sum of the propagation times of:* |
| 5) the paths from the telephone set in country A, to and from the virtual analogue switching points $a_A$ and $b_A$; |
| 6) the two directions of transmission of the international chain; |
| 7) the path $a_B$-$b_B$ of country B. |
| *In addition, there will be needed for fully analogue or mixed analogue/digital connections:* |
| 8) the number of analogue circuits in the 4-wire chain (see Figure 3/G.101). |

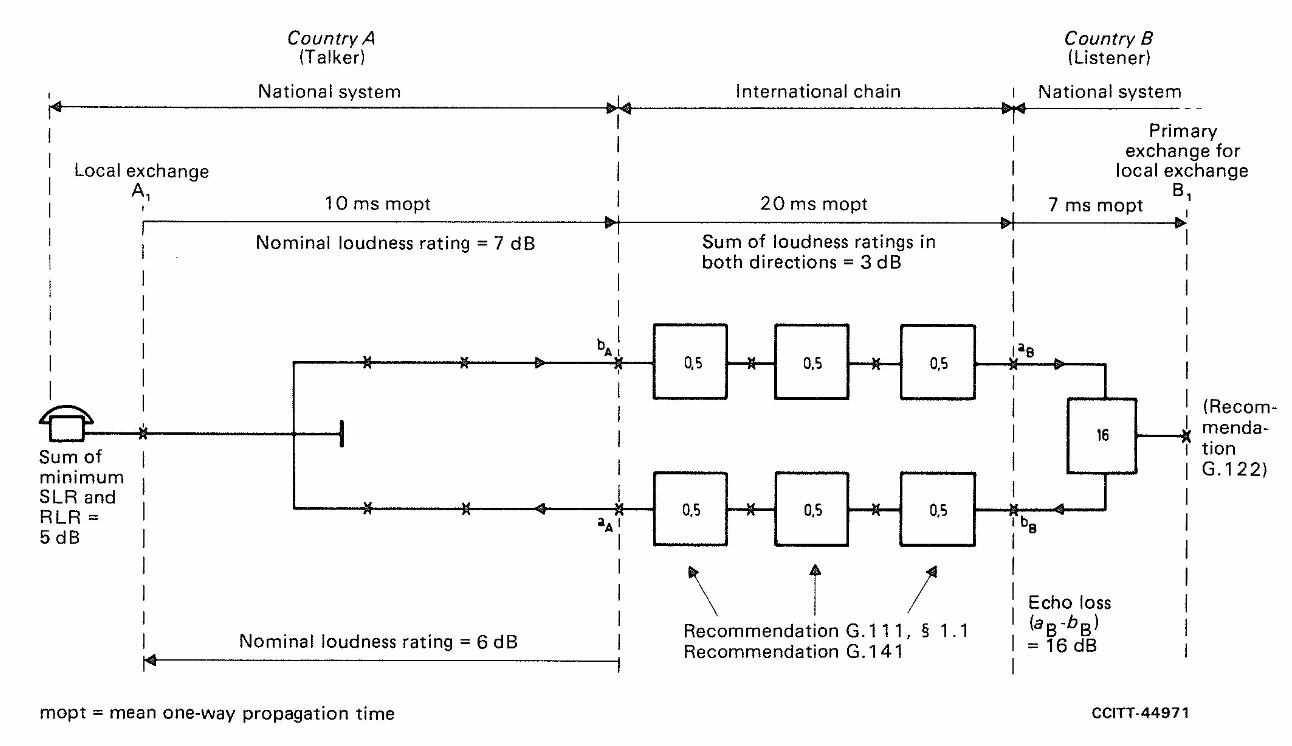



FIGURE A-1/G.131

**Example of application of Figure 2/G.131 to fully analogue connections**

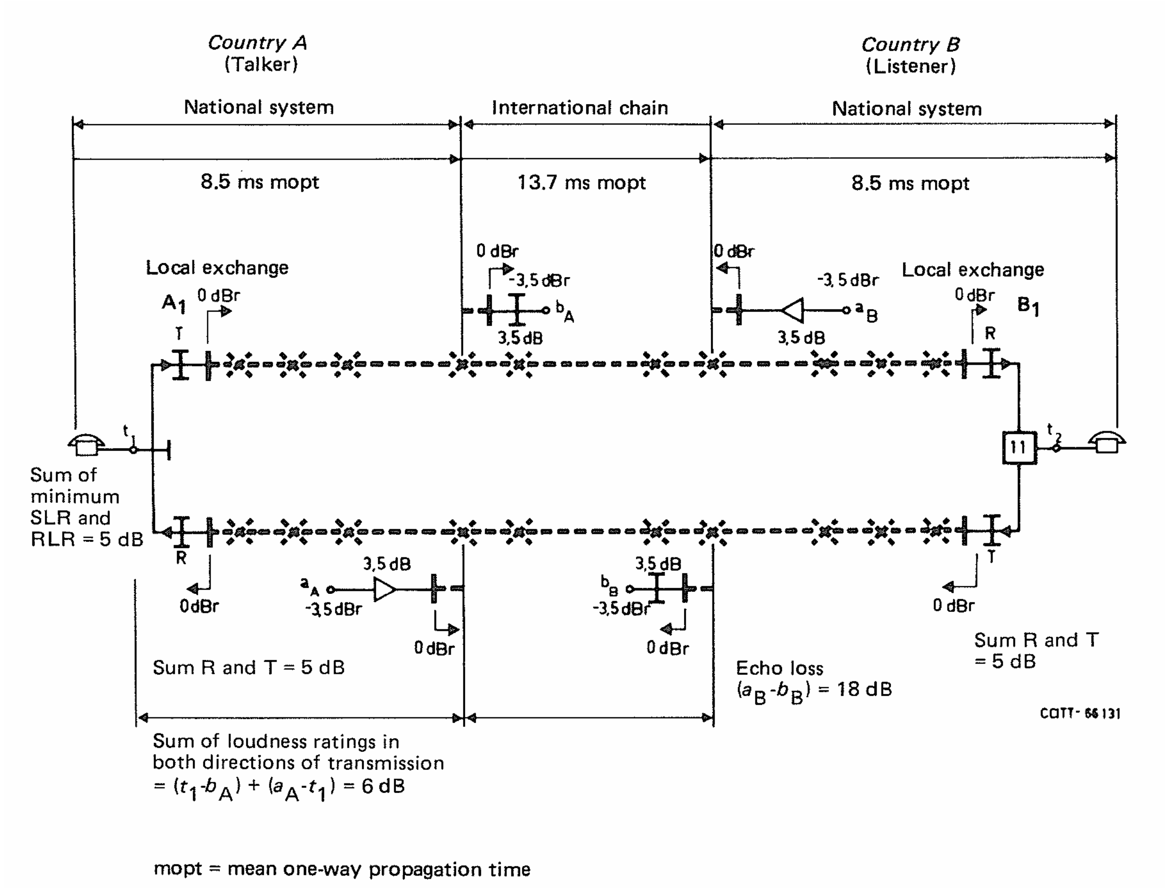



FIGURE A-2/G.131

**Example of application of Figure 2/G.131 to fully digital connections with analogue 2-wire subscriber lines**

A.1 *Full analogue connections* (Figure A-1/G.131)

For the purpose of this Recommendation, it may be assumed that the principal reflection at the listener's end occurs at the 4-wire/2-wire terminating set, which may be assumed to be located at the primary exchange associated with the listener's local exchange. The components of 4) of Table A-1/G.131 are then the losses $a_B$-$t$ and $t$-$b_B$, plus the echo balance return loss at the 2-wire port of the terminating set. This return loss will be the mean overall, of the off-hook subscriber's lines, which may be presented to the 2-wire port of the terminating set by the listener's local exchange. (Figure 2/G.131 assumes that the standard deviation of the return loss is 3 dB.) If the mean value is not known, it may be assumed that 4) of Table A-1/G.131 is in accordance with Recommendation G.122, § 4, viz., a mean value of (15 + $S$) dB where $S$ is the sum of the nominal losses in the two directions of transmission of the circuits in the listener's national 4-wire chain ($S$ is assumed to be 1 dB in this case).

For a given pair of local exchanges, successive connections may encounter different numbers of 4-wire circuits, and the total traffic may be regarded as a number of packets of various proportions encountering from one to nine 4-wire circuits. Each "packet" may be tested with the aid of Figure 2/G.131 and the results combined in order to assess whether Rule A is complied with for the totality of traffic.

Figure A-1/G.131 shows, as an example, an application of Recommendation G.131, § 2, where a listener's $a$-$t$-$b$ path is assumed to be in accordance with Recommendation G.122. For simplicity, it is assumed that 100% of the traffic encounters the given conditions. Values for the example are as follows:

*Talker's country A*

Distance from local exchange $A_1$ to international exchange ........ 1600 km

Mean one-way propagation time from local exchange $A_1$ to international exchange ........ 11 ms[4]

Simultaneous-minimum sending and receiving loudness rating (sum) of the local system ........ 5 dB

Loudness rating from local exchange to international exchange ($b_A$) ........ 7 dB[5]

Loudness rating from international exchange to local exchange ($a_A$) ........ 6 dB[5]

Number of 4-wire circuits ........ 2

*International chain A to B*

Number of circuits ........ 3[6]

Distance ........ 3200 km

Mean one-way propagation time ........ 17 ms[4]

Sum of loudness ratings in both directions 2 × 3 × 0.5 dB ........ 3 dB

*Listener's country B*

Mean echo loss ($a_B$-$b_B$) = (15 + 1) dB ........ 16 dB
(Rec. G.122)

Distance from international exchange to primary exchange associated with local exchange $B_1$
(i.e. point of principal reflection) ........ 1120 km

Mean one-way propagation time corresponding to above distance ........ 16 ms[4]

Number of 4-wire circuits ........ 1

Total number of 4-wire circuits = 2 + 3 + 1 = 6

Total mean one-way propagation time = 11 + 17 + 16 = 44 ms ........ (A-1)

Total loudness rating of the echo path = 5 + 7 + 6 + 3 + 16 = 37 dB ........ (A-2)

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4 Assuming a velocity of propagation for the transmission systems of 250 km/ms, 3 FDM channel modulators and demodulators of 1.5 ms each for talker's country A and the international chain of circuits A to B, and a 12 ms constant for listener's country B (see Recommendation G.114)

5 It is assumed that the loaded trunk-junction introduces an additional 1 dB (in each direction) when changing from nominal transmission loss to loudness rating.

6 An unusually large number, chosen only to illustrate the principle of addition of loss.

If (A-1) and (A-2) are plotted on Figure 2/G.131, the point lies below the 1% line for six 4-wire circuits, indicating a probability of more than 1% of incurring an “unsatisfactory” opinion. The conclusion also applies to other possible numbers of 4-wire circuits.

A.2 *Fully digital connections* (Figure A-2/G.131)

It may be assumed that the principal reflection at the listener's end occurs at the 4-wire/2-wire terminating set, which is located at the listener's local exchange. The components of 4) of Table A-1/G.131 are then the losses $a_B$-$t$ and $t$-$b_B$ plus the echo balance return loss at the 2-wire port of the terminating set. This return loss will be the mean, overall, of the off-hook subscriber's lines, which may be presented to the 2-wire port of the terminating set by the listener's local exchange. (Figure 2/G.131 assumes that the standard deviation of the return loss is 3 dB.) If the mean value is not known, it may be assumed that it is in accordance with Recommendation G.122, § 4.3, viz., a mean value of 11 dB.

In order to apply Figure A-2/G.131 the value of $n$ is not required in this case (as the digital circuits in the 4-wire chain do not contribute to the overall circuit loss variability). However, the number of digital exchanges has an effect on the propagation time, for instance, in accordance with Table 1/G.114, that each digital transit exchange adds 0.45 ms to the mean one-way propagation time of the connection.

Figure A-2/G.131 shows an example where the sum of the R and T pads is either 6 or 7 dB. Values for the example are as follows:

*Talker's country A*

Distance from local exchange $A_1$ to international exchange ........ 1600 km

Mean one-way propagation time from local exchange $A_1$ to international exchange ........ 8.5 ms[7]

Simultaneous-minimum sending and receiving loudness rating (sum) of the local system ........ 5 dB

Sum of loudness ratings in both directions of transmission ($t_1$-$b_A$) + ($a_A$-$t_1$) ........ 6 dB

*International chain A to B*

Distance ........ 3200 km

Mean one-way propagation time ........ 13.7 ms[8]

Loudness rating of international chain ........ 0 dB

*Listener's country B*

Distance from exchange $A_1$ to international exchange ........ 1600 km

Mean one-way propagation time e ........ 8.5 ms[7]

Mean echo loss ($a_B$-$b_B$) = (11 + 7) dB ........ 18 dB

Total mean one-way propagation time = 8.5 + 13.7 + 8.5 = 30.7 ms........ (A-3)

Total loudness rating of the echo path = 5 + 6 + 0 + 18 = 29 dB ........ (A-4)

If (A-3) and (A-4) are plotted on Figure 2/G.131, the point lies below the 1% line (and also the 10% line) for fully digital connections, indicating a propability of more than 1% incurring an “unsatisfactory” opinion.

*Conclusion*

a) An echo control device should be used on the connection; or

b) the loss in the echo path should be increased (but the limitations of Recommendation G.121 must be observed).

*Note* – It should be noted, when contemplating to increase the loss in the echo path, that digital pads placed in digital circuits need to be switched out for digital data signals (but not for voiceband data signals) as they destroy the bit transparency for such signals.

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7 Assuming a velocity of propagation for the transmission systems of 250 km/ms, 4 exchange delays of 0.45 ms each and 0.3 ms delay in the coder or decoder. (In practice a local digital exchange will contribute a little more than 0.45 ms, see Recommendation G.114.)

8 Assuming a velocity of propagation for the transmission systems of 250 km/ms and 2 exchange delays of 0.45 ms each.

A.3 *Mixed analogue/digital connections*

The examples given in Figures A-1/G.131 and A-2/G.131 allow the construction of mixed analogue/digital connection models by combining the appropriate elements of the two figures. The quantities stated in Table A-1/G.131 can be calculated with these models. (Quantity 8) of this table (number of circuits) should now be taken as the number of analogue circuits in the 4-wire chain (thus not including the digital circuits). The appropriate solid curve in Figure 2/G.131 will approximate the required echo tolerance curve with good accuracy.

*Note* - In mixed analogue/digital networks the propagation time can become larger than in purely analogue or digital networks. The latter occurs in particular when digital exchanges are connected with analogue transmission systems through PCM/FDM equipments in tandem or transmultiplexers. Many different configurations may arise.

**References**


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