INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.232

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

INTERNATIONAL ANALOGUE CARRIER SYSTEMS

GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS

12 - CHANNEL TERMINAL EQUIPMENTS

ITU-T Recommendation G.232

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.232 was published in Fascicle III.2 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.232

12-CHANNEL TERMINAL EQUIPMENTS

(amended at Geneva, 1964; further amended)

The CCITT *recommends* that,

except in the particular cases cited in Recommendations G.234 and G.235, channel terminal equipment should provide 12 channels in a basic group, with 4-kHz spaced carrier frequencies, in conformity with the present Recommendation.

1 Attenuation distortion

The following three conditions should be satisfied simultaneously:

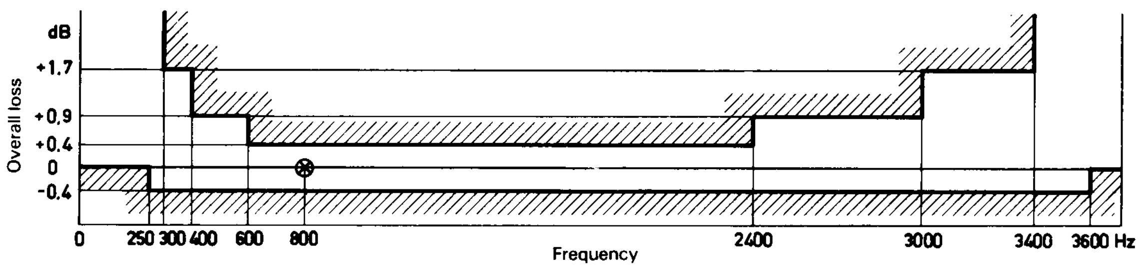
1) The variation with frequency of the mean of the overall losses of the 12 pairs of channel transmitting and receiving equipments of one terminal equipment should not exceed the limits shown in Graph A of Figure 1/G.232.

2) For each pair of channel transmitting and receiving equipments of one terminal equipment, the variation of overall loss with frequency should not exceed the limits shown in Graph B of Figure 1/G.232.

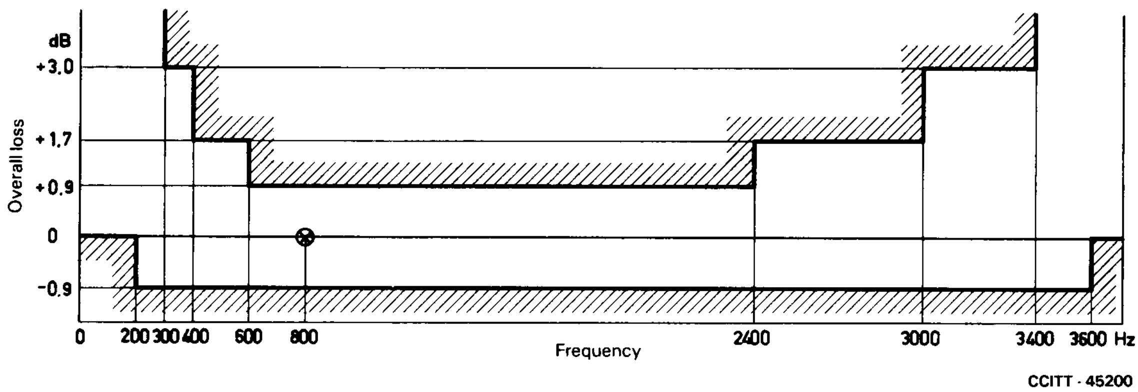
3) For the transmitting equipment of any channel, the attenuation/frequency distortion should not exceed the limits in Graph C of Figure 2/G.232 where:

   - the frequencies shown as abscissae are audio frequencies, before modulation,

   - the ordinates give the limits of relative power level measured at carrier frequency.



Graph A - **Limits for the average variation of overall loss of 12 pairs of equipment of one 12-channel terminal equipment**



Graph B - **Limits for any pair of channel transmitting and receiving equipments**

FIGURE 1/G.232

Permissible limits for the variation with frequency of the overall loss of transmittingand receiving equipments of one 12-channel terminal equipment

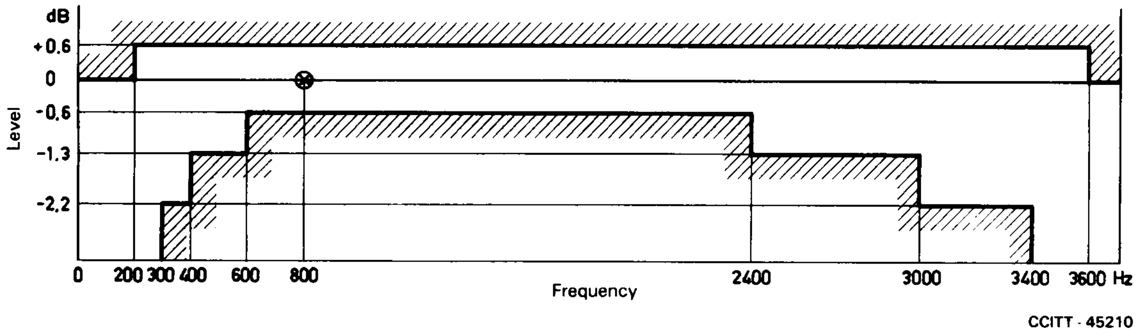


FIGURE 2/G.232

Graph C - **Allowable limits for the variation, as a function of frequency, of the relative power level al the output of the sending equipment of any channel or of the receiving equipment of any channel of a 12-channel terminal**

For the receiving equipment of any channel, the attenuation/frequency distortion should not exceed the limits of this same Graph C where, this time:

- the frequencies shown as abscissae are audio frequencies, after demodulation,
- the ordinates give the limits of relative power level measured at each frequency, at the audio output terminals.

This last recommendation (under 3) above) is based on the assumption that the transmitting and receiving equipments will be treated on an equal footing, and that the overall tolerances will be equally shared between the transmitting and receiving sides.

Note - Some Administrations use, for circuits interconnecting international centres of the higher orders, i.e. CT1s and CT2s (international transit centres), channel-translating equipment that gives an improved loss/frequency response by comparison with equipment meeting the above recommendation. (See [1].) Such equipment does not incorporate outband signalling.

2 Limits for the response outside the band 300 to 3400 Hz

The CCITT recommends that in order to secure the values referred to in Table 1/G.122 of Recommendation G.122 [2], these terminal equipments should show a loss (and not a gain) in relation to the value for 800 Hz at all frequencies below a value f and all frequencies above a value F.

For Graph B of Figure 1/G.232 the recommended values are the following:

f = 200 Hz and F = 3600 Hz

The values recommended for Graphs A and C are:

Graph A: f = 250 Hz and F = 3600 Hz;

Graph C: f = 200 Hz and F = 3600 Hz.

3 Group-delay distortion

The group-delay distortion produced by all types of 4-kHz channel terminal equipment is normally found to be quite acceptable so that no special equalization is needed. To ensure that this remains true for the future, it is recommended that the limits in Table 1/G.232 for the group-delay distortion (relative to the minimum delay) should not be exceeded by a pair of channel transmitting and receiving equipments of one 12-channel terminal equipment.

Group-delay distortion values which are encountered in practice and which are unlikely to be exceeded are 5 ms at 300 Hz and 2.5 ms at 3300 Hz. (This information may be of interest to network designers.)

TABLE 1/G.232

Frequency band	Group-delay distortion
400- 500 Hz	5 ms
500- 600 Hz	3 ms
600- 1000 Hz	1.5 ms
1000- 2600 Hz	0.5 ms
2600-3000 Hz	2.5 ms

4 Stability of virtual carrier frequencies

See Recommendation G.225.

5 Carrier leak

5.1 *Carrier leaks within the basic group band 60-108 kHz*

The carrier leaks are measured at the group distribution frame (or an equivalent point).

The absolute power level of these leaks, referred to a point of zero relative level, should be lower than the following values:

- carrier leak measured on one channel: -26 dBm0;
- sum of carrier leak powers of the various channels, measured within a group: -20 dBm0.

However, if the group is transmitted via open-wire lines over the whole or part of its length, and if it is desired to guard against the risk of conversations over the open-wire line being picked up by an ordinary wireless receiver, the carrier leak must be further reduced.

The place and method to be used for the supplementary suppression of carrier leak, when a group on a cable is transferred to an open-wire line, should be agreed to by the Administrations concerned.

5.2 *Carrier leaks outside the basic group band 60-108 kHz*

Carrier leaks resulting from different methods of modulation (premodulation, pregroup modulation, etc.) may fall outside the frequency band 60-108 kHz and, after group and supergroup modulation, affect adjacent groups and interfere with wideband services. In order to limit such interferences, the power level of any such carrier leak should be lower than -50 dBm0 measured at the group distribution frame, or at an equivalent point.

Note - This value is sufficient for many applications (such as wideband data, etc.). In the case of sound-programme transmission and 3-kHz spaced channels, etc. in the adjacent group, more stringent limits need to be applied (see Recommendation G.233, § 11 and Recommendation G.235, § 5).

6 Protection against harmful voltage surges, clicks, etc.

Experience has shown that it may be necessary to protect equipment against harmful voltage surges arising, for example, from clicks caused by switching equipment or by low-frequency ringing currents.

Some protection against these harmful voltage surges derives from the use by various Administrations of terminations giving a highpass filter effect and having a high loss for frequencies below 300 Hz, or from limiting devices which are either normally fitted in their carrier systems or which can be inserted in the termination. Other arrangements can also be used.

7 Linearity

The curve representing the variation (as a function of power), of the overall loss per channel of a combination of sending and receiving terminal equipments should be within the limits of Figure 3/G.232 (Graph No. 3), the measurements of the output power being made by means of a square law device.

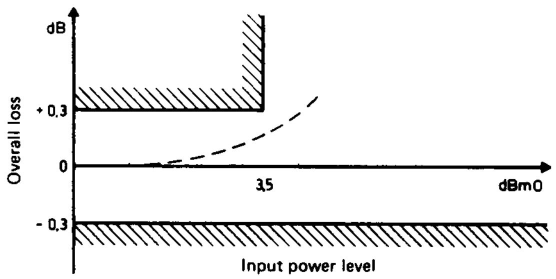


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FIGURE 3/G.232

Graph No. 3 - **Permissible limits for the variation with applied audio power level, of the overall loss of the combination of sending and receiving 12-channel terminal equipments. The curve shows the variation of overall loss as a function of the power level applied to the audio input terminals of one channel and referred to the overall loss when the applied power is 1 mW**

8 Amplitude limiting

The sending equipment of an individual channel, with the addition of a limiter where necessary, must produce the limiting effect defined as follows: for any sine wave signal, at any frequency between 300 and 3400 Hz applied at the input at any level not exceeding 20 dBm0, the level of the high-frequency output signal, measured by means of a quadratic law aperiodic device and referred to zero relative level, should not exceed 12 dBm0.

9 Crosstalk

9.1 *Intelligible intercircuit crosstalk*

The crosstalk ratio (intelligible crosstalk only) measured between two carrier channels of the same group should not be less than 65 dB.

To check that this limit is met, measurement can be restricted to testing with a frequency of 800 Hz with a power of 1 milliwatt at a point which would be at a zero relative power level under normal working conditions. A selective receiving instrument such as a wave analyser can be used.

9.2 *Unintelligible crosstalk between adjacent channels*

The crosstalk produced in an adjacent channel by an unwanted sideband, as a result of imperfect suppression by the channel filter, is inverted and is thus unintelligible. However, such crosstalk may have speech-like rhythm and the annoyance produced by a loud talker should be limited.

To check that the suppression is adequate the following method is applied. The disturbed circuit is terminated at its sending end and the disturbing channel is loaded with a uniform spectrum random-noise signal shaped in accordance with the speech power density curve given in Recommendation G.227.

The power applied to the channel should not exceed 1 mW at a zero relative level point, so as to avoid the influence of the channel limiter.

Using a psophometer, the noise produced in the disturbed channel is then compared with the signal applied to the disturbing channel and the result is expressed as a crosstalk power ratio. The value obtained (making allowance, where necessary, for basic or other noise present on the disturbed channel, independently of the crosstalk being measured) should be at least 60 dB.

9.3 *Go-to-return intelligible crosstalk of any channel within a group*

This recommendation will relate only to intelligible crosstalk measured between the audio-frequency distribution frame and the group distribution frame, including the station wiring (although the crosstalk under consideration comes chiefly from the channel terminal equipments).

The near-end crosstalk ratio measured between the "Audio in" point of each channel and the correspondingly numbered "Audio out" point (see Figure 4/G.232) should be at least *X* dB when the high-frequency access points are suitably terminated.

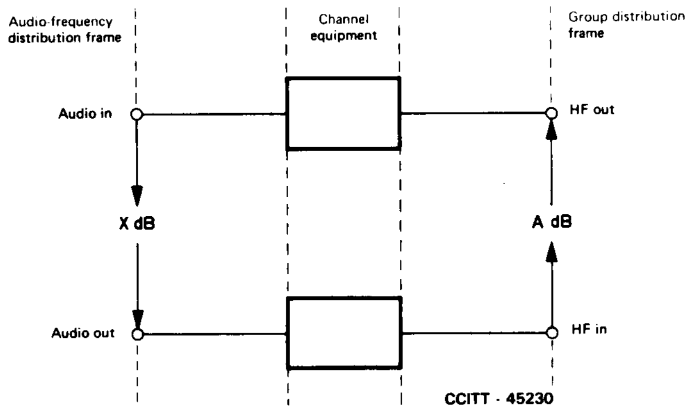

FIGURE 4/G.232

In addition the near-end crosstalk ratio measured between the "HF in" and the "HF out" points should be at least *A* dB when the audio points are appropriately terminated.

The CCITT recommends the following figures which are minimum values to be included in specifications (not objectives):

For all channels X = 53 dB, A = 47 dB. The method of measurement is given in the Recommendation cited in [3].

For channels of circuits which may be used with echo suppressors or call concentrators X = 68 dB, A = 62 dB. The method of measurement is described in the Recommendation cited in [4].

9.4 *Station cabling*

The contribution of the station cabling to go-to-return crosstalk arising in channel translating equipments as measured at audio frequency or group distribution frames should be small, i.e. about an order of magnitude lower than that of the equipment itself. There seems no reason to propose more precise subdivisions of the limits proposed in §§ 9.1, 9.2 and 9.3 above.

Calculation methods

Recommendation J.18 [5] states the various contributory sources to the go-to-return crosstalk which may reasonably be assumed for the near limiting cases which should serve as a basis for equipment specifications.

The Recommendation cited in [6] contains general considerations concerning calculation methods based on power addition of the various contributions.

10 Noise

Recommendation G.222 refers to the noise produced by channel translating equipments.

11 Level, impedance and return loss at audio-frequency terminals

11.1 Taking into consideration the different ways in which Recommendation G.121 [7] can be applied and the modern devices now available, it is recommended that new designs of channel translating equipment should meet the following conditions (see Figure 5/G.232), in which the adjustable attenuation pads A_R and A_S enable the relative levels to be adjusted over a certain range. When these attenuation pads are set to zero loss, the relative level at the S and R terminals of the equipment must have one of the two series of nominal values shown in Table 2/G.232.

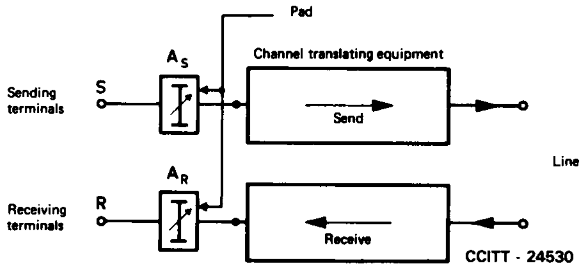

FIGURE 5/G.232

TABLE 2/G.232

	Maximum receive level at *R*	Minimum send level at *S*
Case 1	+4 dBr	-14 dBr
Case 2	+7 dBr	-16 dBr

It was not considered necessary to recommend a value for the adjustment range, which may even be reduced to zero. The choice between these two solutions and the determination of the adjustment range must be left to the Administration involved, taking into account the economical aspects, its own network configuration, its transmission plan and that of the countries with which it will interwork.

11.2 The nominal values of the impedance of the trunk circuits (seen from the manual switchboard jack or from the automatic selector) should be the same for all circuits connected to the same trunk exchange. It is recommended that, if possible, future carrier system terminal equipments should be designed to have a nominal value of 600 ohms for the impedance of national or international trunk circuits.

11.3 The return loss against 600 ohms of the sending and receive terminals with the pads set to zero loss should be better than 15 dB over the frequency range 300-600 Hz and better than 20 dB over the frequency range 600-3400 Hz.

The above limits relate to the intrinsic return loss, i.e. that obtained when the cords connecting the measuring apparatus to the equipment are as short as possible. In view of the station cabling encountered in practice, the return loss recorded at the low-frequency distribution frame may differ from the intrinsic return loss. This factor should be taken into account in designing and establishing the circuits.

Note - In general, when the pad values A_S and A_R - Figure 5/G.232 - are set to values other than zero, better values of intrinsic return loss will be obtained.

12 Levels, impedance and return loss at the high-frequency terminals

Relative power levels and nominal impedance at the high-frequency terminals of channel translating equipment should be selected in accordance with the guidance given in § 3 of Recommendation G.233. In relation to the nominal impedance, return loss at the input and output should not be less than 20 dB in the wanted frequency band. This limit relates to the intrinsic return loss, i.e. that obtained when the cords connecting the measuring apparatus to the equipment are as short as possible. In view of the station cabling encountered in practice, the return loss recorded at the distribution frame of groups may differ from the intrinsic return loss. This factor should be taken into account in designing and establishing the links.

13 Protection and suppression of pilots

With the use of group and supergroup pilots certain problems arise from mutual interference between pilots and between pilots and telephony.

Group and supergroup pilots have been treated separately below where forms of interference, excluding effects of outband signalling, are covered and recommendations made.

Specific recommendations on outband signalling have been excluded[1)]; however, certain general principles and their application to particular outband systems have been included as a guide for an approach to the problem.

Note - Throughout § 13 and in Annexes A and B it is assumed that the pilots used are, on the one hand, at the frequencies 84.080 and 84.140 kHz, and, on the other hand, at 411.920 and 411.860 kHz. If the pilots 104.080 kHz and 547.920 kHz are used, the same provisions apply with the following changes:

Channels 1 and 2 are associated with the group pilot at 104.080 kHz just as channels 6 and 7 are associated with the pilot at 84.080 kHz).

The interference frequency at 64.080 kHz in group 5 and channels 11 and 12 are associated with the supergroup pilot at 547.920 kHz just as the interference frequency at 104.080 kHz in group 3 and channels 1 and 2 are associated with the pilot at 411.920 kHz).

13.1 *Protection and suppression of the group reference pilot*

In view of the various possibilities of interference indicated in Annex A, it is recommended that the terminal equipment of a 12-channel group should conform to the attenuation/frequency requirements of Table 3/G.232.

TABLE 3/G.232

Pilot frequency	Channel No.	Interference frequency in the channel with respect to the carrier	Minimum loss (relative to 800-Hz loss)	
			Send equipement	Receive equipement
(kHz)		(Hz)	(dB)	(dB)
(1)	(2)	(3)	(4)	(5)
84.080	6	3920	20	40
	7	-80	20	20
84.140	6	3860	20	35
	7	-140	30	20

1) *Note by the Secretariat* - See Recommendations Q.21 [8] and Q.414 [9].

The required attenuation at the equivalent frequencies of -80 and 3920 Hz or -140 and 3860 Hz may be obtained by a combination of audio filters, HF channel filters and bandstop filters at the discretion of the Administration concerned. It is, however, noted that, when there is a nonlinear device (such as a channel modulator operated as a limiter, see § 8 above) between audio-frequency and HF, filtration on the audio-frequency filters could have a much reduced effect on high-level audio-frequency interference signals compared with the effect on low-level signals. The relative losses quoted in columns (4) and (5) of Table 3/G.232 are the total effective losses required after the inclusion of a limiter.

All the attenuation values indicated above should be obtained over a band of at least ± 3 Hz relative to the nominal pilot frequency for the pilot at 84.080 kHz and ± 5 Hz for the pilot at 84.140 kHz for both send and receive sides. This bandwidth allows for the tolerances on the pilot (Recommendation G.241, § 3) and for the possible frequency variations on an international circuit (Recommendation G.225, § 1).

In addition, on the send side, the attenuation over a band of ± 25 Hz relative to the nominal frequency of the pilot should be such that the total energy of a white noise signal occupying that bandwidth is attenuated by at least 20 dB (see Annex A). Any unwanted signals falling within this band are liable to be within the passband of the pilot pick-off filter and may cause interference with an automatic gain regulator, measuring equipment, etc.

13.2 *Protection and suppression, of the supergroup reference pilots*

Considerations analogous to those outlined above lead to the recommending of identical values but now applying to channels 1 and 2 of the terminal equipments (instead of channels 6 and 7 respectively). However, the total attenuation required may be obtained, at the discretion of the Administration concerned, either in the channel terminal equipment or in the group-translating equipment (using blocking filters either at 104.140 kHz or 104.080 kHz in group 3 of the group-translating equipment or at 411.860 kHz or 411.920 kHz), or as a combination of the two equipments. The precautions to be taken against such interference in the channel equipment have therefore to be determined in relation to the precautions taken in the group equipment (Recommendation G.233, § 9). The total attenuation required is indicated in Table 4/G.232.

TABLE 4/G.232

Pilot frequency	Disturbing frequency in group 3	Channel No.	Interference frequency in the channel with respect to the carrier	Minimum attenuation (relating to 800-Hz)	
				Sending	Receiving
(kHz)	(kHz)		(Hz)	(dB)	(dB)
(1)	(2)	(3)	(4)	(5)	(6)
411.920	104.080	1 2	3920 -80	20 20	40 20
411.860	104.140	1 2	3860 -140	20 30	35 20

Remarks, the same as in § 12.1 above, relative to the frequency bands in which these values of attenuation are necessary, remain valid in the present case. However, the attenuation in the sending side, within a band of ± 25 Hz relative to the nominal frequency of the supergroup pilot, may with difficulty be obtained at other than voice frequency.

13.3 *Mutual interference between pilots and outband signalling*

In the specification of equipment intended for use with outband signalling, account should be taken of the mutual disturbance between signalling and pilots, and calculation made for each case of the protection necessary as a function of the parameters of the signalling system, according to the following principles:

13.3.1 *Protection of pilots*

When the signalling current is interrupted at the different speeds determined by the signalling code, the level of the signalling interference resulting in a band of 25 Hz on either side of the pilot frequency should remain at least 20 dB below the level of the pilot.

If the transmission of the signalling current is of very short duration compared with the time constant of the regulator, a higher level of interference could be tolerated. Precautions should nevertheless be taken to protect the pilot against continuous transmission of signals under fault conditions.

13.3.2 *Protection of signalling*

It is necessary to ensure that signalling requirements in respect of such factors as signalling, distortion, etc., are met for all outband signalling channels, even when adjacent to a reference pilot frequency.

Note - When an outband signalling system is used, consideration should also be given to the mutual interference of both speech and signalling. In general the attenuation required from this aspect is in itself sufficient to afford protection for pilots.

An example of the application of these rules, where it is assumed that the level of the pilot residue should be no higher than 10 dB below the threshold of sensitivity of the signalling receiver, is considered in Annex B.

14 Interruption control

If it is deemed desirable, e.g. for automatic identification and removal from service of the circuits in faulty groups, a pilot receiver for interruption control purposes can be provided together with the channel translating equipment.

The receiver standardized in Recommendation Q.416 [10] may prove suitable for this purpose, provided that 84.08 or 104.08 kHz are used as pilots.

ANNEX A

(to Recommendation G.232)

Calculation of the attenuation necessary for protection or suppression of pilots

A.1 *Interferences at the end of a group link due to the use of a group reference pilot*

A.1.1 *Disturbance of telephone by group reference pilots*

It is assumed that the maximum level of interference permissible in a telephone channel due to a group reference pilot is -73 dBm0p. The disturbed channels are Nos. 6 and 7.

Table A-1/G.232 below gives the total minimum additional suppression necessary in the receiving channel equipment, between the carrier-frequency input and the audio-frequency output, relative to the nominal loss of the telephony signal.

TABLE A-1/G.232

Pilot frequency (kHz)	Pilot level (dBm0)	Channel No.	Interference frequency in the channel with respect to the carrier (Hz)	Psophometric weighting at the interfering frequency (dB)	Minimum attenuation (dB)
84.080	-20	6 7	3920 -80	13 48	40 5
84.140	-25	6 7	3860 -140	13 31	35 17

Note - Psophometric weights have been rounded off, allowance being made for the tolerances set forth in Recommendation P.53 [l1].

A.1.2 *Disturbance of group reference pilots by telephone channels*

Interference may be caused to the group reference pilots from signals close to or at 80 Hz (84.080-kHz pilot) or 140 Hz (84.140-kHz pilot) in channel 7 and 3920 Hz or 3860 Hz in channel 6. The difficulty here is in defining the character of the interfering signal and that of the instrument suffering from the interference. Certain tests have shown that the major source of interference is sporadic interference (key clicks, mechanical disturbance of microphone, etc.) at low frequencies in channel 7.

However, 20 dB of suppression at 80 Hz from an audio highpass filter was quite adequate when considering the effect on a gain regulator having a long time-constant. The regulator characteristics were as follows*:*

84.080-kHz pick-off filter ± 25 Hz (3-dB points).

Operation of automatic gain regulator (according to r.m.s. value): 4-dB step change in pilot level controlled to 0.2 dB of final value in 45 seconds.

When considering interference on a recorder chart this 20 dB of suppression was found inadequate and 64 dB at 80 Hz was needed with the particular recorder equipment used to ensure interference "spikes" of less than 0.02 dB due to the telephony interference (long-term objective of Recommendation G.241, § 5). Nevertheless, as a general working figure, 20 dB of suppression at 80 Hz (for a pilot frequency of 84.080 kHz) is thought suitable for general recommendation. 3920-Hz interference from channel 6 (again considering the 84.080-kHz pilot) has caused no difficulty with 20 dB suppression and, while less would probably be adequate from the aspect of regulator interference, this figure is nevertheless recommended as one that is readily achieved in channel terminal equipment.

Corresponding figures have been derived for the suppression of interference with the 84.140-kHz pilot from telephony channels. It is assumed here that the energy frequency distribution of the telephony interference accords with the curve of Recommendation G.227. Further, the bandwidth of the pilot measuring filter is assumed to be ± 25 Hz about the pilot frequency, and the permissible interference is the same as that recommended above.

Table A-2/G.232 gives the total minimum additional attenuation necessary in the sending side of channel terminal equipments, between the audio-frequency input and the carrier-frequency output, relative to the nominal attenuation of the telephony signal.

TABLE A-2/G.232

Pilot frequency (kHz)	Pilot level (dBm0)	Channel No.	Interference frequency in the channel with respect to the carrier (Hz)	Minimum attenuation (dB)
84.080	-20	6 7	3920 -80	20 20
84.140	-25	6 7	3860 -140	20 30

A.1.3 *Interference between two-group reference pilots*

A.1.3.1 At the end of a group link where the 60-108 kHz band is broken down to 12 speech channels, the group pilot will give rise to an audio signal in channels 6 and 7 as indicated in § A.1.2 above. If either of these channels is used in the same channel position of a further group link the audio-interference signal will be translated to the frequency of the group pilot and will interfere with the group pilot associated with the second group link.

A total of 40 dB is required to suppress the interference to a tolerable level and this must be obtained in both channels 6 and 7. This loss may, from some aspects, preferably be all in the "receive" side, and from others all in the "send" side.

A generally acceptable working rule, however, is that at least 20 dB be provided in both transmission directions.

A.1.3.2 A further possible source of interference between one group pilot and another is the interconnection between the receive and send sides of a channel 6 or of a channel 7, although only the latter is likely to be significant and need be considered. If the balance return loss at the 2/4-wire termination of channel 7 and the losses of associated circuitry are low at 80 Hz or at 140 Hz, the 80-Hz or 140-Hz signal derived from the incoming group pilot will be reconverted to 84.08 kHz or 84.14 kHz, in the send side and beat with the locally generated outgoing group pilot. The total attenuation in the receive-to-send loop should exceed 40 dB.

A.2 *Interference at the end of a supergroup link or a group link due to the use of a supergroup reference pilot*

Similar considerations apply when a supergroup pilot is used as are set out in § A.1 above in respect of the use of a group pilot, the channels concerned in the case of a supergroup pilot being channels 1 and 2 of group 3. The disturbing frequencies in these channels are 3920 Hz and -80 Hz for the 411.920-kHz pilot, and 3860 Hz and - 140 Hz for the 414.860-kHz pilot.

A.2.1 *Interference with telephony channels by the supergroup reference pilot*

Following the calculations in § A.1.1 above the minimum necessary attenuations are, according to the pilot used:

Channel 1 (receiving): 40 dB at 3920 Hz
35 dB at 3860 Hz

Channel 2 (receiving): 5 dB at -80 Hz
17 dB at -140 Hz

A.2.2 *Interference with supergroup reference pilots by telephone channels*

Following the calculations in § A.1.2 above, the minimum necessary attenuations are, according to the pilot used:

Channel 1 (sending):	20 dB at 3920 Hz 20 dB at 3860 Hz
Channel 2 (sending):	20 dB at -80 Hz 30 dB at -140 Hz

A.2.3 *Interference between two supergroup reference pilots*

Following the considerations of § A.1.3 above a total attenuation of at least 40 dB is necessary at the frequency of a residual signal from a received supergroup reference pilot which, after modulation, is transposed to the frequency of the supergroup reference pilot emitted at the origin of the next supergroup section.

The total attenuation (sending plus receiving) concerns channels 1 and 2.

Moreover, in the case of tandem connection of two groups each occupying position 3 in two supergroups, interference may be produced between the two supergroup reference pilots; hence a total attenuation of at least 40 dB is necessary in the translating equipment of group 3 (sending plus receiving).

ANNEX B

(to Recommendation G.232)

Example of reciprocal protection of pilots and outband signalling

The following three cases may be considered (see Recommendation Q.21 [8]):

- virtual carrier frequency signalling, at level: -3 dBm0;
- 3825-Hz high level: -5 dBm0;
- 3825-Hz low level: -20 dBm0.

A pilot at 84.140 kHz (at a level of -25 dBm0) is associated with virtual carrier frequency signalling and a pilot at 84.080 kHz (at a level of -20 dBm0) with 3825-Hz signalling.

B.1 *Protection of pilots*

Assuming that the signalling current is interrupted at 10 Hz (50 ms-50 ms) one finds that the attenuation necessary in the send side of channel 6 in the signalling or channel equipment is:

- virtual carrier frequency signalling: 21 dB at 3860 ± 25 Hz;
- 3825-Hz high level: 17 dB at 3920 ± 25 Hz;
- 3825-Hz low level: 2 dB at 3920 ± 25 Hz.

B.2 *Protection of signalling*

Assuming that the threshold of sensitivity of the receiver is 11 dB below the nominal level of the signalling, one finds that the attenuation required in the receiving side of channel 6 in the signalling or channel equipment is:

- virtual carrier frequency signalling: zero;
- 3825-Hz high level: 6 dB at 3920 ± 3 Hz;
- 3825-Hz low level: 21 dB at 3920 ± 3 Hz.

References

[1] *Loss-frequency response of channel-translating equipment used in some countries for international circuits,* Green Book, Vol. III-2, Supplement No. 7, ITU, Geneva, 1973.

[2] CCITT Recommendation *Influence of national networks on stability and echo losses in national systems,* Vol. III, Rec. G.122, Table 1/G.122.

[3] CCITT Recommendation *Linear crosstalk,* Vol. III, Rec. G.134, Annex A.

[4] *Ibid.,* Annex A, § A.2.

[5] CCITT Recommendation *Crosstalk in sound-programme circuits set-up on carrier systems*, Vol. III, Rec. J. 18.

[6] *Ibid.,* Annex A.

[7] CCITT Recommendation *Corrected reference equivalent (CREs) of national systems,* Red Book, Vol. III, Rec. G.121.

[8] CCITT Recommendation *Systems recommended for out-band signalling,* Vol. VI, Rec. Q.21.

[9] CCITT Recommendation *Signal sender,* Vol. VI, Rec. Q.414.

[10] CCITT Recommendation *Interruption control,* Vol. VI, Rec. Q.416.

[11] CCITT Recommendation *Psophometers (apparatus for the objective measurement of circuit noise)*, Vol. V, Rec. P.53.