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Recommendation G.231

ARRANGEMENT OF CARRIER EQUIPMENT

(amended at Geneva, 1964; further amended)

1 Carrier-system racks (formerly Part A)

The CCITT,

considering

that countries not having a national industry for the construction of carrier systems must obtain them from different factories, and that the variations of the dimensions of the racks between different sources of supply do not allow of a simple and economical layout of the cables and efficient use of accommodation,

unanimously recommends

that in future the dimensions of carrier-system racks should meet the requirements as follows:

1) *Space between suites* — The minimum space between suites should be such that it is possible to move test trolleys from place to place (between two suites), and also for maintenance staff to be able to work comfortably between two suites. A spacing of 75 cm at least seems reasonable.

2) *Overall height* — The overall height of a rack above the floor (not including the space provided for overhead cable runs) should not exceed 320 cm.

In principle, 30 cm should be allowed for overhead cable runs, and also about 30 cm for access to these cables, which makes at the most 60 cm between the top of the rack and the ceiling; nevertheless, some Administrations consider that a total height of 40 cm between the top of the rack and the ceiling is sufficient in certain cases. In main repeater stations (or terminal equipment stations), where, in addition to cables connecting one rack to another, general distribution cables have to be allowed for, it is recommended that the height of the building between the floor and the ceiling should be at least 4 m to facilitate access to the various cables.

3) *Thickness* — The thickness of a rack should not be greater than 45 cm. For racks which may be placed back to back the total suite thickness may be up to 52 cm, including all maintenance controls, cooling fins, etc., which may protrude from the nominal face of the equipment.

This recommendation applies both to carrier systems and to audio equipment.

2 Use of standard components in transmission equipment (formerly Part B)

While acknowledging that the International Electrotechnical Commission (IEC) is competent to devise standards for components or devices generally used in electrical engineering, the CCITT nevertheless reserves the right to issue recommendations dealing with such equipment and with transmission systems which, if components standardized by the IEC were used, may prove impossible to create.

Furthermore, manufacturers and Administrations wishing to use components specified by the IEC or by another body will still be responsible for ensuring that the recommendations issued by the CCITT are met.

Hence the CCITT *recommends*

that Administrations and manufacturers should ensure that all components used in transmission systems and equipments (even if such components have been standardized by some other national or international body) are such that the requirements of CCITT recommendations will be complied with in the conditions of use envisaged, throughout the life of the equipment or systems, i.e. twenty years or more.

3 **Power supply** (formerly Part C)

Information on noise at the terminals of the battery power supply system is given in Supplement No. 13 [1].

For carrier system equipment, it is recommended that power supply equipment should provide a no-break supply when the power mains fail.

Note — Much existing equipment has been designed in accordance with the old recommendation in Volume III of the *Blue Book* (1964) which is reproduced below:

‘‘In countries where the main power supply is unreliable and where it is the normal source of supply for the coaxial system, it is recommended that in each power-feeding station there should be equipment to transfer from the normal source of supply to a standby source or vice versa in such a manner that breaks in transmission on voice-frequency telegraph circuits or on telephone circuits with automatic signalling carried by the system do not exceed about 150 milliseconds.’’

4 **Repeater station cabling** (formerly Part D)

The Administrations mentioned in the list kept by the CCITT Secretariat are prepared to supply other Administrations and technical assistance experts working under the ITU with information on the national standards they apply to the wiring of repeater stations. However, they would warn users that cable specifications and wiring diagrams are not always the best way of giving them the information they desire. The documentation available is very bulky and requests for information should be reasonably precise, since it is essential to know exactly on what point information is required in order to decide what form the reply should take.

A proper understanding of how wiring is done in repeater stations cannot be acquired from documents alone and the persons concerned should get in touch with the Administrations on the list in order to see the methods put into practice.

Administrations are invited to supply information to keep this list, which is deposited with the CCITT Secretariat, constantly up to date.

Reference

[1] *Noise at the terminals of the battery supply* , Orange Book, Vol. III-3, Supplement No. 13, ITU, Geneva, 1977.

Recommendation G.232

12-CHANNEL TERMINAL EQUIPMENTS

(amended at Geneva, 1964; further amended)

The CCITT *recommends* | hat,

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.

Figure 1/G.232, p.

figure 2/G.232, p.

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:

$$f = 200 \text{ Hz and } F = 3600 \text{ Hz}$$

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 (maintenu) T1.232, p.

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.

figure 3/G.232 p.

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 p.

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 p.

Table 2/G.232 (maintenu) T2.232, p.

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 ; however, certain general principles and

Note by the Secretariat — See Recommendations Q.21 [8] and Q.414 [9].

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 (maintenu) T3.232, p.

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 ± | Hz relative to the nominal pilot frequency for the pilot at 84.080 kHz and ± | 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 ± | 5 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 (maintenu) T4.232, p.

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 ± **|** 5 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 (maintenu) T5.232, p.

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 ± | 5 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 ± | 5 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 (maintenu) T6.232, p.

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.

Recommendation G.233

RECOMMENDATIONS CONCERNING TRANSLATING EQUIPMENTS

(amended at Geneva, 1964; further amended)

This Recommendation concerns translating equipments with the exception of:

— channel-translating equipment, in respect of which Recommendations G.232, G.234 [1] and G.235 should be consulted;

— equipment for translation into the line-frequency band; the Recommendations relating to the various line systems should be consulted.

1 Translating procedure

The procedures whereby the translating equipments defined in Recommendation G.211 translate basic groups, supergroups and mastergroups or a basic 15-supermastergroup assembly (No. 1) are represented by the following figures:

1) Figure 1/G.233 for group-translating equipments (procedures 1 and 2);

2) Figure 2/G.233 for supergroup-translating equipments (procedure 1);

3) Figure 3/G.233 for mastergroup-translating equipments (procedure 1);

4) Figure 4/G.233 for supergroup-translating equipments (procedure 2);

5) Figure 5/G.233 for translating equipments for basic 15-supergroup assembly (No. 1) (procedure 2).

Note — Equipments 4 and 5 above are peculiar to procedure 2 described in Recommendation G.211. The conditions in which this procedure is used are described in that Recommendation.

Figure 1/G.233, p.

Figure 2/G.233, p.

Figure 3/G.233, p.

Figure 4/G.233, p.

Figure 5/G.233, p.

2 Adjustment of level at basic group-frequency points

When a group passes through different carrier systems, it is necessary to provide for an adjustment of level: for example, between the limits of about ± | dB, wherever the group passes through the basic frequency range.

3 Relative power levels at group distribution frames and supergroup distribution frames

Although the standardization of the relative power levels at group distribution frames and supergroup distribution frames would be desirable to facilitate the setting-up and maintenance of international carrier systems and routing changes of groups or supergroups from one system to another, it was not possible before the Plenary Assembly of 1972 to recommend such a standardization internationally, because of the diversity of carrier systems already in service. Table 1/G.233 shows, for information, the level used by different Administrations.

The CCITT concerned itself solely with recommending preferred values for countries which have not yet fixed these values for their national networks. Accordingly:

— a relative sending level of —36 dBr is recommended at group and supergroup distribution frames;

— for reception, it is recommended that a choice be made between —23 dBr and —30 dBr;

— the following values are recommended for the impedance:

150 ohms balanced for group distribution frames,

75 ohms unbalanced for supergroup distribution frames.

H.T. [T1.233]

TABLE 1/G.233

Relative power levels at the basic group and supergroup distribution frames in the carrier systems of various Administrations

Country					
	Transmit (dBr)	Receive (dBr)			Receive (dBr)
Federal Republic of Germany 150 ohms, **150** balanced	—36.**5**	—30.**5**			
	—35.**8**	—30.**5**	75 ohms, unbalanced		
	System 1	—36.5	—30.5		
	—35.**8**	—30.5	id.		
	System 2	—42.**5**	— 5.**5**		
	—35.**8**	—30.**5**	id.		
Austria 75 ohms, **150** unbalanced	—37.**5**	— 8.**5**			
	—35.**8**	—30.**5**	id.		
150 ohms, **150** balanced	—36.**5**	—30.**5**			
Belgium 150 ohms, **150** balanced	—37.**5**	— 8.**5**			
	—35.**8**	—30.**5**	id.		
People's Republic of Bulgaria 150 ohms, **150** balanced	—36.**5**	—23.**5**			
	—36.**8**	—23.**5**	id.		
Spain, Ireland, New Zealand, Norway, United Kingdom 150 ohms, **150** unbalanced	—37.**5**	— 8.**5**			
	—35.**8**	—30.**5**	id.		

{ USA (American Telephone and Telegraph Company) }	—42.**5**	— 5.**5**	{
135 ohms, **150** balanced }	—25.**8**	—28.**5**	id.
France	—33.**5**	—15.**5**	{
150 ohms, **150** balanced }	—45.**8**	—35.**5**	id.
Hungary, Italy, Netherlands	—37.**5**	—30.**5**	{
150 ohms, **150** balanced }	—35.**8**	—30.**5**	id.
India	—36.5	—30.4	{
150 ohms, **150** balanced }	—34.8	—30.4	id.
{ Japan (Nippon Telegraph and Telephone Public Corporation) }	—36.**5**	—18.**5**	{
75 ohms, **150** balanced }	—29.**8**	—29.**5**	id.
{ Mexico (Tel´efonos de M´exico) }	—47.**5**	—10.**5**	{
150 ohms, **150** balanced }	—47.**8**	—24.**5**	id.
People’s Republic of Poland	—36.**5**	—23.**5**	{
150 ohms, **150** balanced }	—36.**8**	—23.**5**	id.
German Democratic Republic	—36.**5**	—23.**5**	{
150 ohms, **150** balanced }	—36.**8**	—23.**5**	id.
Sweden	—35.**8**	—30.**5**	id.
Switzerland	—36.5	—30.5	{
75 ohms, **150** unbalanced }	—35.**8**	—26.**5**	id.
USSR	—36.**5**	—23.**5**	{
150 ohms, **150** balanced }	—36.**8**	—23.**5**	id.

a) System 1 only.

Table 1/G.233 [T1.233], p.

4 Relative power levels at mastergroup distribution frames

The relative power levels at mastergroup distribution frames (see Figure 6/G.233) should be adjusted to the following values:

— transmit: —36 dBr,

— receive: —23 dBr,

across a 75-ohm impedance, unbalanced to earth.

figure 6/G.233, p.

5 Relative levels at supermastergroup distribution frames

Relative power levels at supermastergroup distribution frames should be adjusted to the following values:

— transmit: —33 dBr,

— receive: —25 dBr,

across a 75-ohm impedance, unbalanced to earth.

6 Relative levels at the distribution frame of 15-supergroup assembly (No. 1)

The relative power levels at the 15-supergroup assembly distribution frame should be adjusted to the following values:

— send: —33 dBr,

— receive: —25 or —33 dBr,

across a 75-ohm impedance, unbalanced to earth.

7 Return loss

In relation to the nominal impedance, the return loss at the input and output of the translating equipment of supergroups, mastergroups, supermastergroups and 15-supergroup assemblies should not be lower than 20 dB in the wanted frequency band for both directions (send and receive) of transmission.

With respect to the group translating equipment, the same limit applies at the high-frequency side; at the low-frequency side, it is also valid except in those areas in the vicinity of the group and supergroup pilots such as:

— the band 103.7-104.6 kHz of group 3 when there is a stop filter for the 411.920 kHz pilot;

— the band 63.7-64.6 kHz of group 5 when there is a stop filter for the 547.920 kHz pilot.

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 distribution frame of groups, supergroups, etc., may differ from the intrinsic return loss. This factor should be taken into account in designing and establishing the links.

8 Noise

Recommendation G.222, § 4 gives information on the noise produced by group, supergroup, mastergroup and 15-supergroup assembly translating equipment.

9 Interference related to supergroup reference pilot

Interference from, or with, supergroup reference pilots may be avoided by taking suitable precautions in channel terminal equipments or group-translating equipment (see Recommendation G.232, § 13.2 and the Recommendation cited in [2]).

9.1 *Pilots at 411.860 and 411.920 kHz*

9.1.1 For the protection of pilots at a through-connection point (see Recommendation G.243), group 3 should at the receive end of a supergroup link be through-connected without demodulation, for example to another supergroup link; the modulating equipment for group 3 should present an attenuation of at least 20 dB at the frequency of the supergroup pilot.

9.1.2 Moreover, when an Administration wishes to route 8- or 12-channel groups free between one supergroup link and another with no restrictions on routing of group 3, then the group 3 modulating and group 3 demodulating equipment should each provide in all cases at least 20 dB suppression at the frequency of the supergroup reference pilot.

9.2 *Pilot at 547.920 kHz*

If this pilot is used in a supergroup transmitting five groups (regardless of the use made of these groups) and not a wideband signal (for data, etc.) occupying most of the frequency band, the arrangements mentioned in § 9.1 above for the group 3 equipment should be adopted in the modulating and demodulating equipment of group 5.

10 Accuracy of carrier frequencies

See Recommendation G.225, § 1).

11 Carrier leaks

11.1 The carrier leak at the transmit side of a modulation stage should not exceed:

—47 dBm0 for group modulation,

—50 dBm0 for supergroup modulation,

—45 dBm0 for mastergroup modulation,

—50 dBm0 for supermastergroup modu lation and 15-supergroup assembly modulation,

—30 dBm0 for 15-supergroup assemblies Nos. 2 and 3 on 12-MHz a nd 60-MHz systems, and for the first modulation stage of 15-supergroup modulation on 60-MHz systems, since in this case the carrier leaks fall into bands of frequencies not used for traffic.

11.2 Higher levels of carrier leaks can be tolerated at the output of a modulation stage at the receive side, provided no interference with adjacent groups, etc. occurs (e.g. by way of backward carrier leak, etc.)

11.3 In the case of sound-programme transmission according to the Recommendation cited in [3] certain channel carrier leaks, pre-group carrier leaks etc. falling in adjacent groups may cause excessive interference. In order to meet Recommendation cited in [4] the level of such leaks, measured at the supergroup distribution frame or an equivalent point, should not be higher than the values indicated below:

—75 dBm0 in the frequency ranges 73-82 kHz and 86-95 kHz,

—55 dBm0 at 67 kHz and 101 kHz.

In the frequency bands 67-73 kHz and 95-101 kHz the requirements are based on straight lines (linear frequency and dB scales) connecting the limits indicated above.

Note 1 — It is recognized that there are several possibilities of meeting this recommended limit, such as allocating the necessary attenuation wholly or partly to the channel or group translating equipment respectively, to insert special filters at the group distribution frame, or by selection of groups.

Note 2 — The above limit is applicable to the transmit side only.

Note 3 — The 7 dB margin between the Recommendation cited in [4] and § 11.3 above allows for cumulation on the group links involved.

11.4 In the case of 3-kHz spaced channels, the following recommendations apply:

When a baseband carries 3-kHz or a mixture of 3- and 4-kHz channels, the level of each carrier leak should not exceed the value given in Table 2/G.233 (limits apply to transmit path only).

Table 2/G.233 (maintenu) T2.233, p.

The filters of the supergroup translating equipment may contribute to the suppression of the group 4 and 5 carrier leaks.

Special attention is also necessary to avoid backward carrier leaks in the demodulation stage that may result in a product falling into a 3-kHz channel in either the group or supergroup demodulation stage.

Note — No allowance has been given for cumulation. The effects of cumulation are offset at least in part by the noise masking effect of long interconnected sections that commonly accompany the use of 3-kHz channel equipments.

12 Go-to-return crosstalk

The following limits are recommended for crosstalk ratios (single frequency measurements) for group and higher order translating equipments; they will apply to both the low and high frequency sides:

— group translation: 80 dB;

— higher order translation stages: 85 dB.

Note — On the basis of telephony considerations alone, a limit of 80 dB would have been proposed for all translation stages; this would also have sufficed to meet the recommended limit for intelligible crosstalk between programme circuits (74 dB in Recommendation J.21 [5]) in networks where programme circuits are systematically equipped with compandors. However, importance was attached to adopting a single requirement for each translation stage which would suffice for the most demanding network conditions to be encountered.

13 Group-delay distortion

13.1 *Group translating equipment*

It is recommended that the limits in Figure 7/G.233 for the group-delay distortion (relative to the value at 84 kHz) should not be exceeded by a group translating equipment consisting of a pair of group transmitting and receiving equipments. The given values are applicable to groups 2, 3 and 4 (without additional pilot stop filters). Groups 1 and 5 are excluded due to additional distortions caused by various sources (pilot stop filters, position at the end of the supergroup band, etc.); group 3 may be excluded, when the supergroup pilot 411.92 kHz or 411.86 kHz is used.

Note — The range of measured values on modern equipments is indicated in Supplement 17 at the end of this fascicle.

Figure 7/G.233, p.

13.2 *Supergroup translating equipment*

It is recommended that the limits in Figure 8/G.233 for the group-delay distortion (relative to the value at 412 kHz) should not be exceeded by a supergroup translating equipment consisting of a pair of supergroup transmitting and receiving equipments. The given values are not applicable to supergroups 1 and 3. Depending on the design of supergroup translating equipment this restriction may also apply to supergroups 6 and 7 (due to pilot protection filter).

Note — The range of measured values on modern equipments is indicated in Supplement 17 at the end of this fascicle.

Figure 8/G.233, p.

References

[1] CCITT Recommendation *8-channel terminal equipments* , Orange Book, Vol. III-1, Rec. G.234, ITU, Geneva, 1977.

[2] *Ibid* ., § f) 2.

[3] CCITT Recommendation *Characteristics of equipment lines used for setting up 15-kHz type sound-programme circuits* , Vol. III, Rec. J.31, § 1.

[4] *Ibid* ., § 2.

[5] CCITT Recommendation *Performance characteristics of 15-kHz type sound-programme circuits* , Vol. III, Rec. J.21.

Recommendation G.234

8-CHANNEL TERMINAL EQUIPMENTS

(Geneva, 1964; further amended)

(For the text of this Recommendation, see Volume III of the *Orange Book* , Geneva, 1976)

Recommendation G.235

16-CHANNEL TERMINAL EQUIPMENTS

(Geneva, 1964; further amended)

In the exceptional cases where this presents a very important economical advantage, for example in submarine cable systems where the line equipment is very costly by comparison with the terminal equipment, the CCITT recognizes the use of channel terminal equipments giving 16 telephone channels in a group with 3-kHz channel spacing, conforming to the detailed requirements of the present Recommendation as well as to the compatible requirements of Recommendation G.232. This equipment does not ensure meeting the overall objective of Recommendation G.132 [1].

It is pointed out that carrier systems over lines on land which are the subject of CCITT Recommendations have been drawn up on the assumption that they will be used with 4-kHz-spaced terminal equipments: it is not always possible to use such systems with 3-kHz-spaced terminal equipments. The use of this equipment results in increased system loading (see Recommendation G.371, § 3).

1 Allocation of frequencies in a group

Sixteen channels should appear in the basic group band 60-108 kHz, the channels being numbered 1 to 16 in order of decreasing frequency. The relative channel position and the virtual carrier frequencies should be:

— lower sidebands of

105.15 99.15 93.15 87.15 81.15 75.15 69.15 63.15 kHz;

— upper sidebands of

104.85 98.85 92.85 86.85 80.85 74.85 68.85 62.85 kHz.

Note 1 — It should be noted that this frequency allocation does not permit the transmission of the 16-channel group in the normal through-group equipment without cutting off the high frequencies of the extreme channels.

Note 2 — Transmission of such a group within a supergroup, and in a wideband system, calls for special elimination of the leaks from certain neighbouring group and supergroup carrier currents which, having frequencies that are multiples of 4 kHz, fall within certain channels.

2 Attenuation distortion

The transmit and receive sides should each meet the characteristics of Figure 1/G.235 with reference frequency of 800 Hz or 1000 Hz.

Figure 1/G.235, p.

3 Group delay

The following conditions should be met both by sending and receiving equipments:

— group delay at 1000 Hz, | ms;

— over the band 565-2550 Hz the difference between the maximum and minimum group delay should not exceed 0.75 ms;

— over the bands 300-565 Hz and 2550-3000 Hz, the group delay should not exceed the value at 1000 Hz by more than 2 ms.

4 Stability of virtual carrier frequency

The channel carrier oscillators should be within ± | .1 Hz of the nominal frequency. The carriers of subgroups (if such are used) should be multiples of 4 kHz derived from the central carrier generators and will therefore have the same good frequency stability as the latter.

5 Carrier leak

The level of each carrier leak should not exceed:

—70 dBm0 for each channel carrier current;

—60 dBm0 for any second sta ge modulation carrier current when its frequency is within 52-116 kHz;

—73 dBm0 for any second stage modu lation carrier frequency falling outside the band 52-116 kHz;

—73 dBm0 for each harmonic of the channel and subgroup carrier leaks.

6 Limiting and linearity

When a 1000-Hz signal is applied to a channel, the variation in sending equipment gain as the signal level is changed should lie within the limits below, the reference gain being zero with a 0 dBm0 input:

—60 to +4 dBm0; gain: 0 ± 0.1 dB,

input level: +15 dBm0; gain: between —3 and —5 dB.

7 Crosstalk

7.1 Crosstalk ratio (corresponding only to intelligible crosstalk) between the two directions of transmission of each circuit should not be less than 65 dB.

7.2 If random noise at a level of 0 dBm0, weighted in accordance with the curve in Figure 2/G.227 is applied to a channel on the sending side, the resulting interference on other channels should not exceed —60 dBm0p.

8 Noise

The basic noise in each transmit and receive channel should not exceed —73 dBm0p psophometrically weighted.

9 Pilots

9.1 Use of group and supergroup pilots as envisaged by Recommendation G.241 is impossible. A group pilot of 84 kHz and a supergroup pilot of 444 kHz are normally used. It is recommended that the levels of the second harmonic of 444 kHz should not exceed —73 dBm0 and that the level of any other harmonic of these pilots should not exceed —75 dBm0. The point where these limits should be met is the distribution frame (or equivalent point) at the output of the next higher stage of modulation, e.g. the supergroup frame in the case of the group pilot. Account should be taken of the change of frequency.

9.2 See Recommendation G.241 for the more stringent limits which must be applied to harmonics of pilots of 4-kHz spaced channel assemblies when they are used in systems which also contain 3-kHz spaced channel assemblies.

9.3 Where pilots of 300 kHz or 308 kHz are used on line systems it is recommended that the level of any harmonic should not exceed —73 dBm0, except that the second harmonic of 300 kHz should not exceed —75 dBm0.

Reference

[1] CCITT Recommendation *Attenuation distortion* , Vol. III, Rec. G.132.

2.4 Utilization of groups, supergroups, etc.

Recommendation G.241

PILOTS ON GROUPS, SUPERGROUPS, ETC.

(amended at Geneva, 1964; further amended)

1 Use of pilots

Experience has shown that, without the use of a group pilot transmitted throughout a group link, adequate stability of the channels of individual group links cannot be guaranteed in spite of the care given to the maintenance of the carrier systems on which they are routed.

It may be necessary, in the first place, to place an automatic regulator, controlled by the pilot, at the end of some of the group sections forming the group link to compensate for inevitable variations in attenuation on each of the sections. This regulator is not, of course, designed to correct automatically for faults.

It is desirable for the regulator to have a range of at least ± | dB. While no maximum range is specified, note should be taken that too great a range can prove unsatisfactory, e.g. due to noise or the masking of faults. A maximum range of approximately ± | dB has been found satisfactory by some Administrations.

An alarm should be given when the amplitude of the pilot at the input of the regulator departs from its nominal value by more than ± | dB. The conditions governing the use of these regulators are given in Recommendation M.160 [1].

It is also necessary to provide for measuring the level of the group pilot at the ends of group sections where it is not planned to use a regulator. In these cases, too, an alarm should be given when the level of the pilot departs from its nominal value by more than ± | dB.

Precisely similar considerations apply to the use of supergroup, mastergroup and supermastergroup pilots, and also to the use of basic 15-supergroup assembly pilots.

Note — When a group is through-connected from a cable section (on coaxial or symmetric pairs) to an open-wire line, transmission of the group pilot over the open-wire line, which is an advantage as regards maintenance of the complete group can, to a certain extent, facilitate ‘‘tapping’’ of conversations by means of radio receivers of a particular type in the territory traversed by the open-wire line. However, this risk of ‘‘tapping’’ is less than the similar risk arising from inadequate suppression of the carrier, because the frequency of the group pilot is more remote from the nearby carrier frequency, so that the quality of the overheard conversation would be necessarily degraded.

2 Nominal characteristics of pilots (group, supergroup, etc.)

When group, supergroup, etc., pilots are considered necessary, they should be permanently transmitted.

The frequency and the level of these pilots are shown in Table 1/G.241.

Table 1/G.241 (maintenu 1 corr. par Montage) T1.241, p.

3 Tolerances on the sent level of pilots

The following values are recommended for the frequency accuracy of the various pilots:

Pilot frequency 84.080 kHz and 411.920 kHz ± | 1 Hz

Pilot frequency 84.140 kHz and 411.860 kHz ± | 3 Hz

Pilot frequency 104.080 kHz and 547.920 kHz ± | 1 Hz

Pilot frequency 1552 kHz ± | 2 Hz

Pilot frequency 11 | 96 kHz ± | 0 Hz

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This pilot, after modulation of the 15-supergroup assembly to position No. 3 (see procedure 2 of Recommendation G.211, § 1) appears at the frequency 11 096 kHz; this is identical with the frequency of the basic supermastergroup pilot.

Note — These tolerances can be taken as a basis for the specifications of the associated pilot receiving filters and stop filters, allowance also being made for recommendations concerning the accuracy of master oscillators.

The following recommendations are made concerning the tolerances for the sent pilot level:

1) The design of equipment should be such as to allow the sum of errors in the level of any group, etc., pilot as transmitted, due to finite level adjustment steps, change in number of groups supplied, and lack of adjustment facilities in individual groups, to be kept within ± | .1 dB.

2) The change in output level of the pilot generator with time (which is a factor included in equipment specifications) must not exceed ± | .3 dB during the interval between two maintenance adjustments, e.g. in one month.

3) To reduce pilot level variations with time, it is advisable to have a device to give an alarm when the variation at the generator output exceeds ± | .5 dB, the zero of the warning device being aligned as accurately as possible with the lining-up level of the transmitted pilot.

The attention of Administrations is drawn to the difficulty which could result from an appreciable reduction in the absolute power level of the pilot sent to line; such a reduction is liable to cause ‘‘near singing’’, resulting from the operation of the automatic gain-control amplifiers. It would be desirable to make arrangements for overcoming this difficulty if it should arise.

4 Harmonics of pilots

4.1 It is recommended that the levels of harmonics of group and supergroup pilots should not exceed the values given in Table 2/G.241. The point where these limits should be met is the distribution frame (or equivalent point) at the output of the next higher stage of modulation, e.g. the supergroup distribution frame in the case of the group pilot. Account should be taken of the change of frequency.

Table 2/G.241 (maintenu) T2.241, p.

4.2 In the case of the pilot (1552 kHz) for a mastergroup, it is recommended that the level of the second harmonic of the pilot should not exceed —50 dBm0 and the level of each other higher harmonic should not exceed —75 dBm0 measured at the output of the next higher stage of modulation.

4.3 In the case of the pilot (11 | 96 kHz) for a supermastergroup, it is recommended that the level of any harmonic should not exceed —75 dBm0 measured at the output of the next higher stage of modulation.

4.4 In the case of the pilot (1552 kHz) for 15-supergroup assemblies, it is recommended that the level of the second harmonic should not exceed —50 dBm0, measured at the output of the supergroup translating equipment.

Where the 15-supergroup assembly is not combined with other assemblies, there is no particular requirement on the level of the third and higher harmonics.

Where the 15-supergroup assembly is combined with other assemblies, the level of the third and higher order harmonics should not exceed —75 dBm0, measured at the combined output.

5 Protection of group, supergroup, etc., pilots against interference by noise

Automatic regulators operated by group, supergroup, etc., reference pilots should be so designed that the interfering effect of noise does not exceed 0.02 dB for any significant period. If, for example, the regulator operates on the mean signal voltage, this corresponds to a long-term interfering signal of —20 dB relative to the pilot level. When the interference is of short duration compared with the time constant of the regulator, high levels of interference may be experienced without causing an error in regulation exceeding 0.02 dB.

5.1 *Group and supergroup pilots*

If the pilot pick-off filter has a bandwidth of 50 Hz (25 Hz on each side of the nominal pilot frequency) the ratio between pilot and noise will always be considerably greater than 20 dB in the case of carrier systems over land-lines. This ratio is still respected if the unweighted power of the noise in a telephone channel reaches 10^6 pW at zero relative level (level of —30 dBm0), which very rarely occurs on radio-relay links conforming to the conditions of Recommendation G.441.

In the case of very long group or supergroup links on such radio-relay links, the pilot-to-noise ratio will be smaller than 20 dB only for a period of less than some ten-thousandths of any month. In that case the resultant error in regulation will be negligible, as the duration of the very high-level noise will be short compared with the necessarily long time-constant of the regulator. In any case, such high-level bursts are not expected to occur with any significant frequency and the chief factor limiting the interference caused to a pilot by noise is therefore the effective bandwidth of the pick-off filter.

5.2 *Other pilots*

Similar consideration applies also to mastergroup, supermastergroup and basic 15-supergroup assembly pilots. However, the bandwidth of the pick-off filter will certainly be greater than 50 Hz and more reliance will have to be placed on the relatively long time-constant of the regulator to minimize the effect of short-duration high-level noise.

Note 1 — Recommendations concerning the protection and suppression of pilots at certain points appear in Recommendation G.243.

Note 2 — When use is made of procedure 1, described in Recommendation G.211, the spacing between the 11 **|** 96 kHz supermastergroup pilot and the audio-frequencies transposed in the adjacent channels is 28 kHz and 60 kHz.

This same spacing is only 4 kHz with procedure 2, described in Recommendation G.211.

In view of this, a supermastergroup regulator is not necessarily suitable for the transmission of a 15-supergroup assembly over a supermastergroup link.

6 Protection of group or supergroup pilots against signals transmitted in telephone channels

This protection is ensured in the channel and group translating equipment, in accordance with Recommendations G.232, § 12 and the Recommendation cited in [4].

7 Protection of group or supergroup link pilots transmitting wide-spectrum signals

7.1 To protect the group or supergroup link pilots (used to establish wideband circuits) against other wide-spectrum signals (data, facsimile, etc.), it is recommended that the power spectrum emitted about the pilot frequency be limited in the equipment which transmits these signals. This limitation is so calculated that the group or supergroup regulators installed on the link will not receive interference of more than 0.1 dB, and the values to be specified therefore depend on the characteristics of the regulators (passband of the pilot filters, regulation operating time constant).

With regard to continuous spectrum signals, the spectrum density in the band $f_0 \pm | 5$ Hz must not exceed —70 dBm0/Hz.

The limits to be set for discrete components are fixed by the Figure 1/G.241 which allows for the existing characteristics of regulators activated by pilots at frequencies (f_0) of 84.08 or 104.08 kHz in group links and of 411.92 or 547.92 kHz in supergroup links.

Such a limitation of the transmitted spectrum, obtained by a suitable choice of modulation characteristics, dispenses with the need to insert a bandstop filter to protect the pilot (such a filter would introduce harmful distortion of the group delay). However, if it is not possible to impose such a limitation on the emitted spectrum by this method, or if no guarantee can be secured that this limitation will be respected, the Administrations operating the transmission networks should, in order to protect the group regulators against interference caused by the wideband signals, insert bandstop filters (which would produce the smallest possible distortion to the group delay) at the input of the group or supergroup links under consideration, producing the limitation indicated by Figure 1/G.241.

Note — The general problem of protecting the reference pilots from interference when a group or supergroup is used for the transmission of wide-spectrum signals arises because the protection of these pilots is not always secured by means of a band-clearing filter connected immediately before injection of the pilot. In normal telephone use such protection may depend upon the existence of filters in telephony channel or group translating equipment; however, these may not be in circuit when a wideband transmission path is set up.

Figure 1/G.241, p.

The use of a group containing the supergroup pilot should always be avoided (see Recommendation H.14 [5]). This means that no special suppression of the wideband signal has to be provided in the group for the purpose of the supergroup pilot.

7.2 *''Delayed transfer''*

It may be imagined that some data-processing devices record the wideband signal in the form in which it reaches them from the network, and then retransmit this recorded signal over the network on a group or supergroup link. On this assumption, the pilot will be recorded at the same time as the signal; it will therefore be retransmitted with it and will then interfere with the pilot injected on the new link. In this case, the recording or retransmitting device should be equipped with a frequency-stop filter providing an attenuation of at least 40 dB at the pilot frequency under consideration, and contributing as little distortion as possible to the group delay. However, if Administrations have inserted, at the input of wideband links, the cut-off filter for protection of the pilot as mentioned in § 7.1 above, the aim sought in the present paragraph will have been reached and the frequency-stop filter will be superfluous.

7.3 *Multipoint links*

In the case of multipoint links on tree-shaped networks, the pilot should be blocked at each confluence point on all the confluent links except one, by means of a filter like the one mentioned in § 7.2 above, leaving only one pilot protected against interference from the other pilots. It is also possible to block the pilots on all the confluent links and to transmit a locally produced pilot beyond that point of the link.

References

[1] CCITT Recommendation *Stability of transmission* , Vol. IV, Rec. M.160.

[2] CCITT Recommendation *8-channel terminal equipments* , Orange Book, Vol. III-1, Rec. G.234, ITU, Geneva, 1977.

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

[4] CCITT Recommendation *8-channel terminal equipments* , Orange Book, Vol. III-1, Rec. G.234, § f), ITU, Geneva, 1977.

[5] CCITT Recommendation *Characteristics of group links for the transmission of wide-spectrum signals* , Vol. III, Rec. H.14.

Recommendation G.242

THROUGH-CONNECTION OF GROUPS, SUPERGROUPS, ETC.

(amended at Geneva, 1964; further amended)

1 General considerations

It may be found desirable from both the technical and the economical points of view to provide facilities at the end of certain sections such that the channels routed over one section do not all have to be extended to the next section, this being done without demodulating all the channels to voice frequency, whole batches of channels being extended to different line sections.

At such points, which are at the ends of the *line links* concerned, the through-connection of batches of telephone channels should be possible from one line link to another. This can be achieved by means of the following two methods which, though basically different, can nevertheless be used in association at a given point for different batches of channels. In both cases arrangements are necessary to ensure that the through-connected frequency band is ''clear'', that is to say, as far as possible the channel vestiges on the two sides of the through-connected batch of channels should be suppressed by means of a through-connection filter.

This Recommendation does not consider certain precautions necessary for the protection of various pilots and additional measuring frequencies. Such precautions are given in Recommendation G.243.

1.1 *Through-group, supergroup, mastergroup, supermastergroup or 15-supergroup assembly*

It is assumed that the batch of through-connected channels occupies the frequency band of a group, supergroup, mastergroup, supermastergroup or 15-supergroup assembly, or that it can be split into several such bands. Each of the groups, supergroups, mastergroups, supermastergroups or 15-supergroup assemblies is then brought into the basic frequency band and is filtered in that band by means of a through-group filter, or through-supergroup, through-mastergroup, through-supermastergroup or through-15-supergroup assembly filter.

Note — The frequency band occupied by the 15-supergroup assembly No. 3 (8620 to 12 | 36 kHz) is within the frequency band occupied by the basic supermastergroup (8516 to 12 | 88 kHz). Hence, when 15-supergroup assemblies are used in the conditions specified in Recommendation G.211 (procedure 2), 15-supergroup assembly No. 3 can be through-connected by means of through-supermastergroup filters.

1.2 *Direct through-connection*

It is also possible to through-connect a group, supergroup, mastergroup, supermastergroup or 15-supergroup assembly or a batch of them by direct line filtration without demodulation and passage via the basic frequency band. It is then necessary to have direct through-connection filters connected to the line equipment to effect the necessary separation. An example of this possibility is given in Recommendation G.333 for the 60 MHz system.

In fixing the degree of suppression of unwanted components, it is convenient to use the following definitions:

intelligible crosstalk components

F: composantes de diaphonie intelligible

S: componentes de diafon´ia inteligible

Transferred speech currents which can introduce intelligible crosstalk into certain channels at the point considered.

unintelligible crosstalk components

F: composantes de diaphonie inintelligible

S: componentes de diafon´ia ininteligible

Transferred speech currents which can introduce unintelligible crosstalk into certain channels at the point considered.

possible crosstalk components

F: composantes possibles de diaphonie

S: componentes posibles de diafon´ia

Transferred speech currents which, at the point considered, do not intrude into the channels of other systems but which may do so elsewhere.

harmful out-of-band components

F: composantes extra-bandes nuisibles

S: componentes fuera de banda perjudiciales

Transferred currents arising from speech, or pilots, or additional measuring frequencies, and of frequencies such that they will always lie outside the useful frequency band (corresponding to speech frequencies) of the carrier systems, but which may interfere with pilots or additional measuring frequencies.

harmless out-of-band components

F: composantes extra-bandes neutres

S: componentes fuera de banda neutras

Transferred currents arising from speech or pilots which, at all translation points, have frequencies outside the useful frequency band corresponding to audio frequencies or pilot frequencies.

The term ‘‘wanted component’’ is applied below in respect to speech band, to an 800-Hz signal with a power of 1 milliwatt sent to a zero relative level point, and in respect of pilots or additional measuring frequencies, to the signal of specified frequency and level at the point where it is normally injected.

2 Through-group connection

2.1 *Ratio between the wanted and unwanted components*

In the case of through-connection of a group, the ratio between the wanted components and the various unwanted components defined above should be:

1) intelligible crosstalk components: 70 dB;

2) unintelligible crosstalk components: 70 dB;

3) possible crosstalk components: 35 dB wherever possible components appear;

4) harmful out-of-band components: 40 dB;

5) harmless out-of-band components: 17 dB.

All these separations must be provided by the transfer filter itself. They relate to the nominal level, 84 kHz which is the reference frequency (close to the group pilots) at which the loss of the group transfer filter is set. At the other frequencies, account should be taken of the tolerance allowed for the distortion loss of this filter.

At any temperature between 10 | (deC and 40 | (deC, insertion loss for all the through-group connection equipment at any frequency of the passband (60.6 to 107.7 kHz) should not depart from the loss at 84 kHz by more than ± | dB.

The loss between 10 | (deC and 40 | (deC at 84 kHz should not differ by more than ± | dB from the loss at 25 | (deC.

Note 1 — It would be technically difficult for the CCITT to recommend a distribution of these overall limits among the equipments mentioned in footnote 2 on this page.

Note 2 — The value of 70 dB shown in 1) and 2) above for the intelligible or unintelligible crosstalk components is the minimum standard value for telephony. A value of 80 dB is recommended in the band which, in each group adjacent to the through-connected group, corresponds to the band 84 to 96 kHz in the basic group and which may therefore be used for programme transmissions by systems, whether or not equipped with compressors having the characteristics defined in Recommendation J.31, § 1.5 [1].

This condition should be fulfilled both when the adjacent group is direct and when it is inverted.

Note 3 — As a consequence of the condition in Note 2 above, in each through-connected group, the value recommended will also be achieved in the band corresponding to the band 72 to 84 kHz in the basic group.

Note 4 — The values recommended above for the intelligible or unintelligible crosstalk components are also compatible with the use of 15 kHz circuits (Recommendation J.21 [2]) and 7 kHz circuits (Recommendation J.23 [3]) for programme transmission. Consideration is given to the fact that the equipments used to set up these circuits (Recommendation J.31 [1] and Annexes, Recommendation J.34 [4]) are single sideband systems with compandors or double sideband systems. Account was also taken of the frequency band occupied by the programme channels of the equipments in the basic group and of the frequency response characteristics of the weighting network referred to in Recommendation J.16 [5].

This equipment comprises a group demodulation equipment, the through-group filter proper and a group modulation equipment.

If 16-channel groups be used, the passband must be extended from 60.1 to 107.9 kHz or, by agreement between the Administrations concerned, the band indicated in the present recommendation must be kept, in which event Note 1 to Recommendation G.235 will have to be carefully borne in mind.

Slightly different loss limits apply outside the band occupied by the telephone channels when out-of-band signalling is used; this point can be settled on the national level or by agreement between the Administrations concerned.

2.2 *Group-delay distortion of the through-group filter*

In the case of through-connection of a group in the basic frequency band 60-108 kHz, it is recommended that the limits in Figure 1/G.242 for the group-delay distortion (relative to the value at 84 kHz) should not be exceeded by the through-group filter.

Note — The range of measured values on modern equipments is indicated in Supplement 17 at the end of this fascicle.

Figure 1/G.242, p.

3 Through-supergroup connection

3.1 *Ratio between the wanted and unwanted components*

In the case of through-connection of a supergroup, the ratio between the wanted components and the various unwanted components defined above should be:

1) intelligible crosstalk components: 70 dB;

2) unintelligible crosstalk components: 70 dB;

3) possible crosstalk components: 35 dB wherever possible components appear;

4) harmful out-of-band components: 40 dB ;

5) harmless out-of-band components: 17 dB.

All these separations must be provided by the through-supergroup filter itself. They relate to the nominal level 412 kHz, which is the reference frequency (close to the supergroup pilots), at which the loss of the supergroup transfer filter is set. At the other frequencies, account should be taken of the tolerance allowed for the distortion loss of this filter.

At any temperature between 10 | (deC and 40 | (deC, insertion loss for all the through-supergroup connection equipment at any

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The specified attenuation should be met at the nominal frequencies of the pilots and additional measuring frequencies involved (at a point where these are 308 kHz or 556 kHz) in accordance with the definition of harmful out-of-band components.

This equipment comprises a supergroup demodulation equipment, the through-supergroup filter proper and a supergroup modulation equipment.

frequency of the passband (312.3 to 551.4 kHz should not depart from the loss at 412 kHz by more than ± | dB.

Slightly different loss limits apply outside the band occupied by the telephone channels when out-of-band signalling is used; this point can be settled on the national level or by agreement between the Administrations concerned.

The loss between 10 | (deC and 40 | (deC at 412 kHz should not differ by more than ± | dB from the loss at 25 | (deC.

Note 1 — It would be technically difficult for the CCITT to recommend a distribution of these overall limits among the equipments mentioned in footnote 6 above.

Note 2 — The ratio of 70 dB shown in 1) and 2) above for the intelligible or unintelligible crosstalk components is a minimum standard value for telephony. A separation of 80 dB is advocated for the bands liable to be used for programme transmission in each supergroup adjacent to the transferred supergroup.

Note 3 — In the case of through-connection of supergroup 1 or 3, the range of insertion loss of the combined through-supergroup equipment can reach 3 dB in the passband of the filter around 312 kHz or 552 kHz.

3.2 *Group-delay distortion of the through-supergroup filter*

In the case of through-connection of a supergroup in the basic frequency band 312-552 kHz, it is recommended that the limits in Figure 2/G.242 for the group-delay distortion (relative to the value at 412 kHz) should not be exceeded by the through-supergroup filter.

Note — The range of measured values on modern equipments is indicated in Supplement 17 at the end of this fascicle.

Figure 2/G.242, p.

4 Through-mastergroup connection

For the through-mastergroup connection, the ratio between wanted components and the various unwanted components defined above should be:

1) intelligible crosstalk components: 70 dB;

2) unintelligible crosstalk components: 70 dB;

3) possible crosstalk components: 35 dB wherever possible components appear;

4) harmful out-of-band components: 40 dB ;

The specified attenuation should be met over a band corresponding to the recommended frequency stability of the original frequencies of the pilots or the additional measuring frequencies involved (where these are translated to 768 kHz or 2088 kHz)in accordance with the definition of harmful out-of-band components.

5) harmless out-of-band components: 17 dB.

All these ratios should be achieved by the through-mastergroup filter itself. They refer to the nominal level of the 1552-kHz reference frequency (mastergroup pilot) by which the loss of the through-mastergroup filter is fixed. At other frequencies, the attenuation/frequency distortion tolerance allowed for this filter should be taken into consideration.

At any temperature between 10 | (deC and 40 | (deC, the loss at any frequency within the passband (812 to 2044 kHz) of the combined through-mastergroup equipment should not deviate by more than ± | dB from the loss at 1552 kHz.

The loss between 10 | (deC and 40 | (deC, at 1552 kHz, should not deviate by more than ± | dB from the loss at 25 | (deC.

Within each supergroup the total variation of the insertion loss should not exceed ± | dB relative to the loss at the frequency of the supergroup reference pilot.

Note — The ratio of 70 dB shown in 1) and 2) above for intelligible or unintelligible crosstalk components is a minimum standard value for telephony. A separation of 80 dB is advocated for the bands liable to be used for programme transmission in each mastergroup adjacent to the transferred mastergroup.

5 Through-supermastergroup connection

For the through-supermastergroup connection, the ratio between wanted components and the various unwanted components defined above should be:

1) intelligible crosstalk components: 70 dB;

2) unintelligible crosstalk components: 70 dB;

3) possible crosstalk components: 35 dB; wherever possible components appear;

4) harmful out-of-band components: 40 dB ;

5) harmless out-of-band components: 17 dB.

All these ratios should be achieved by the through-supermastergroup filter itself. They refer to the nominal level of the 11 | 96 kHz reference frequency (supermastergroup pilot) by which the loss of the combined supermastergroup equipment is fixed. At other frequencies the attenuation/frequency distortion tolerance allowed for this filter should be taken into consideration.

At any temperature between 10 | (deC and 40 | (deC, the insertion loss at any frequency within the passband 8516 to 12 | 88 kHz of the combined through-supermastergroup equipment should not deviate by more than ± | .5 dB from the loss at 11 | 96 kHz. Within each mastergroup the total variation in insertion loss should not exceed ± | dB relative to the loss at the frequency of the mastergroup pilot.

The loss between 10 | (deC and 40 | (deC, at 11 | 96 kHz, should not deviate by more than ± | dB from the loss at 25 | (deC.

Note — The ratio of 70 dB shown in 1) and 2) above for intelligible or unintelligible crosstalk components is a minimum standard value for telephony. A separation of 80 dB is advocated for the bands liable to be used for programme transmission in each supermastergroup adjacent to the transferred supermastergroup.

This equipment comprises a mastergroup demodulation equipment, the through-mastergroup filter proper, and a mastergroup translating equipment.

The specified attenuation should be met over a band corresonding to the recommended frequency stability of the original frequencies of the pilots or the additional measuring frequencies involved (after frequency translation of the supermastergroup into the basic 8516-12 | 88 kHz band) in accordance with the definition of harmful out-of-band components.

This equipment comprises the supermastergroup demodulation equipment, the through-supermastergroup filter proper and supermastergroup translating equipment.

6 Through-15-supergroup assembly connection

For through-15-supergroup assembly (No. 1) connection, the ratio between wanted components and the various unwanted components defined above should be:

1) intelligible crosstalk components: 70 dB;

2) unintelligible crosstalk components: 70 dB;

3) possible crosstalk components: 35 dB wherever possible components appear;

4) harmful out-of-band components: 40 dB ;

5) harmless out-of-band components: 17 dB.

All these ratios should be achieved by the through-15-supergroup filter itself. They refer to the nominal level of the 1552-kHz reference frequency (frequency of the basic 15-supergroup assembly pilot) by which the loss of the through basic 15-supergroup assembly No. 1 filter is fixed. At other frequencies, the attenuation/frequency distortion tolerance allowed for the filter should be taken into consideration.

This equipment comprises the 15-supergroup assembly demodulation equipment, the through-connection filter (if any) and the 15-supergroup assembly-translating equipment.
Alternatively, the above ratios may be provided by a through-connection equipment that incorporates the necessary filtering within the 15-supergroup assembly demodulator and the 15-supergroup assembly modulator.

At any temperature between 10 | (deC and 40 | (deC, the loss at any frequency within the passband (312 to 4028 kHz) of the combined through-15-supergroup equipment should not deviate by more than ± | .5 dB from the loss at 1552 kHz.

The loss between 10 | (deC and 40 | (deC at 1552 kHz should not deviate by more than ± | dB from the loss at 25 | (deC.

Within each supergroup, the total variation of the insertion loss should not exceed ± | dB relative to the loss at the frequency of the supergroup reference pilot.

Note — The ratio of 70 dB shown in 1) and 2) above for intelligible or unintelligible crosstalk components is a minimum standard value for telephony. A separation of 80 dB is advocated for the bands liable to be used for programme transmission in each 15-supergroup assembly adjacent to the transferred 15-supergroup assembly.

7 Direct through-connection

The values recommended for the attenuation of the various crosstalk components are the same as those given in §§ 2 to 6 above for through-connection of groups, supergroups, etc., in as far as they are not in contradiction with those recommended in Recommendation G.243, § 5.

References

[1] CCITT Recommendation *Characteristics of equipment and lines used for setting up 15 kHz type sound-programme circuits* , Vol. III, Rec. J.31.

The specified attenuation should be met over a band corresponding to the recommended frequency stability of the original frequencies of the pilots or the additional frequencies involved (after frequency translation of the 15-supergroup assembly into the basic 312-4028 kHz band) in accordance with the definition of harmful out-of-band components.

[2] CCITT Recommendation *Performance characteristics of 15 kHz type sound-programme circuits* , Vol. III, Rec. J.21.

[3] CCITT Recommendation *Performance characteristics of narrow-bandwidth sound-programme circuits* , Vol. III, Rec. J.23.

[4] CCITT Recommendation *Characteristics of equipment used for setting up 7 kHz type sound-programme circuits* , Vol. III, Rec. J.34.

[5] CCITT Recommendation *Measurement of weighted noise in sound-programme circuits* , Vol. III, Rec. J.16.

Recommendation G.243

PROTECTION OF PILOTS AND ADDITIONAL MEASURING FREQUENCIES AT POINTS WHERE

THERE IS A THROUGH-CONNECTION

(amended at Geneva, 1964; further amended)

1 Interconnection of telephone circuits at audio frequency

It is necessary that the interconnection of telephone circuits at audio frequency may be made without restriction and without causing interference between the sent and received group and supergroup pilots. It is therefore recommended that Recommendations G.232, § 13 and G.234 [1] be met, which specify an attenuation of at least 20 dB in both modulating and demodulating equipments for the leaks of group pilots (channels 6 and 7 or 1 and 2) and supergroup pilots (channels 1 and 2 or 11 and 12).

2 Through-group connection

2.1 *Group routed on a supergroup equipped with pilots 411.860 and 411.920 kHz*

To permit unrestricted through-group connection without causing interference between the sent and received supergroup pilots Recommendation G.233, § 9.1.2, has to be followed. Otherwise, it is necessary at least to follow Recommendation G.233, § 9.1.1 and, moreover, to avoid routing a through group in position 3 in two successive supergroup links.

2.2 *Group routed on a supergroup equipped with pilot 547.920 kHz*

The same provisions as in § 2.1 apply, but to the group in position 5 and not in position 3 (in accordance with Recommendation G.233, § 9.1.2.

3 Through-supergroup connection

3.1 *Protection of a line-regulating pilot against additional measuring frequencies*

To prevent interference with a line-regulating pilot lying adjacent to a through-connected supergroup, arising from an additional measuring frequency on an adjacent line link, it is recommended that the combined through-supergroup equipment, plus any additional blocking filter (e.g. associated with the through-supergroup equipment or provided as a pilot suppression filter immediately preceding the point on the line at which the line-regulating pilot is injected) should provide the following discrimination (relative to 412 kHz):

— over the range 308 kHz ± 8 Hz, not less than 40 dB;

— over the range 308 kHz ± 40 Hz and the range 556 kHz ± 40 Hz, not less than 20 dB.

Note 1 — In making this recommendation, it has been assumed that the addition of the various frequency components within pilot-operated line regulators will follow a square or average law of addition.

Note 2 — If, by mutual agreement, Administrations use an auxiliary line-regulating pilot, an additional attenuation giving a discrimination of at least 40 dB relative to the attenuation at 412 kHz should be provided over a suitable frequency range around

556 kHz and in particular in the range 556 kHz ± 10 Hz in the case of a 2792-kHz pilot, for which the CCITT has recommended that the frequency variations should not exceed ± | Hz.

Note 3 — When the synchronizing or frequency-checking pilot is also a line-regulating pilot (multipurpose pilot), then where it passes from one regulated-line section to another, the pilot should be blocked and reintroduced (after filtration) on the following regulated-line section after its amplitude has been corrected.

3.2 *Protection of additional measuring frequencies*

To minimize interference between additional measuring frequencies on adjacent line sections and to prevent interference between additional measuring frequencies on non-adjacent line sections, it is recommended that through-supergroup equipment should provide the following discrimination (relative to 412 kHz):

— over the range 308 kHz ± 50 kHz and the range 556 kHz ± 50 Hz, not less than 15 dB;

— over the range 308 kHz ± 20 Hz and the range 556 kHz ± 20 Hz, not less than 20 dB;

— at frequencies of 308 kHz and 556 kHz, not less than 40 dB.

3.3 *Protection of the mastergroup or 15-supergroup pilot against additional measuring frequencies*

To prevent interference with the mastergroup or 15-supergroup pilot arising from additional measuring frequencies, it is recommended that the through-supergroup equipment, plus any necessary additional blocking filter, should provide the following discrimination relative to 412 kHz:

— over the range 308 kHz ± 7 Hz and the range 556 kHz ± 7 Hz, 50 dB;

— over the range 308 kHz ± 40 Hz and the range 556 kHz ± 40 Hz, 30 dB.

Any necessary additional blocking filter should be provided in association with the equipment where the 1552 kHz pilot is injected, that is, in the supergroup translating equipment on the sending side where the mastergroup or 15-supergroup assembly is formed.

Figure 1/G.243 recapitulates all the attenuations recommended over the range 308 kHz and 556 kHz.

Figure 1/G.243, p.

4 End of a supermastergroup link

The supermastergroup pilot should be blocked at the end of a supermastergroup link, unless otherwise agreed between Administrations. The end of a supermastergroup link shall be considered as any point where basic supermastergroup working is no longer used, even though the supermastergroup may not be broken up into mastergroups at that point.

For example, in the case described in Figure 2/G.243, point M is the end of a supermastergroup link, at which point the supermastergroup pilot should not be transmitted to country B (even though the supermastergroups continue to be transmitted to line without demodulation), unless country B agrees to depart from this rule. Moreover, country B, which does not use the basic supermastergroup, is not required to transmit this supermastergroup pilot over the link PM.

In any case, the supermastergroup pilot is considered as blocked when it undergoes an additional attenuation of 40 dB.

Figure 2/G.243, p.

5 Direct through-connection

Let B be a repeater station where one or several supergroups, mastergroups, supermastergroups or 15-supergroup assemblies are through-connected by direct filtering from a line section AB on to another line section BC (see Figure 3/G.243). At point B special precautions should be taken with respect to pilots and additional measuring frequencies, so that these signals are transmitted to certain line sections where it is desired to route them but, on the other hand, do not interfere with pilots of the same type transmitted on other sections.

Figure 3/G.243, p.

If the supergroups are in the basic supergroup frequency band, this becomes the case dealt with in § 3.

5.1 *Precautions to be taken in the use of pilot signals and additional measuring frequencies where there is direct through-connection within a regulated line section*

5.1.1 *Line-regulating pilots*

When the regulation of line section BD is to be performed together with the regulation of line section AB (and with that section only), the regulated line section extends from A to D and point B is not the end of the regulated line section AB. If one or two line-regulating pilots are outside the frequency band of the supergroups, mastergroups or supermastergroups diverted over BD, or lie at the edge of this frequency band, special arrangements must be made at point B for these pilots to be extended beyond B on to section BD (see Recommendation G.213, § 1 General Remarks, 2).

In the direction of C, however, the line-regulating pilots of section AB should be stopped, in the same conditions as at the end of the regulated-line section, so as not to be transmitted on section BC.

5.1.2 *Additional measuring frequencies*

At a station where there is direct through-connection and which is within a regulated-line section (station B of section AD in the preceding example) the additional measuring frequencies within the frequency bands of the supergroups, mastergroups or supermastergroups are diverted as a whole.

It may not be possible to use additional measuring frequencies at the edges of a through-connected frequency band because the amplitudes of these frequencies are affected by the direct through-connection filters. It might therefore be desirable in certain cases to specify ‘‘measuring sections’’ over which these additional measuring frequencies would be used. The choice of such measuring sections is left to the discretion of the Administrations concerned.

5.1.3 *Other pilot frequencies*

In each particular case, the Administrations concerned should decide on the points where the synchronizing or frequency-checking pilot and any switching pilot should be blocked so as not to interfere with other parts of the link. However, should one of these pilots also be a line-regulating pilot (multipurpose pilot) the rules defined above for line-regulating pilots should be applied.

5.2 *Precautions to be taken at a direct through-connection point at the end of a regulated-line section*

5.2.1 *Line-regulating pilots*

If it is not desired to associate the line regulation of section AB with that of the other sections, point B is, by definition, the end of a regulated line in section AB and the line-regulating pilots of this section AB should be stopped in such a way that, on all the interconnected sections (in this case, BC and BD), they are at least 40 dB below the pilots used on these sections.

When some (or all) of the pilots used on line-regulating section AB are not on the same frequency as those used on a line-regulating section connected to it, suppression of these pilots by 20 dB only (which implies a residue of not more than —30 dBm0 on the connected line-regulating section) may be tolerated at direct through-connection point B, if this residue is further suppressed by 20 dB before reaching the injection point of a line-regulating pilot with the same frequency on another line-regulating section connected at a distant point (for example, at D). However, the line-regulating pilot should be suppressed by 40 dB whenever it is applied to an international line-regulated section crossing at least one frontier. It therefore follows that the line-regulating pilot should be suppressed by 40 dB if the following section is an international section, even with a line-pilot at a different frequency.

Similarly, if a line-regulating pilot is suppressed by 20 dB only, a supplementary attenuation of 20 dB must be introduced on the line frequency at the end of the corresponding line-regulating section before this pilot residue reaches a distant international section.

With reference to the example in Figure 1/G.213, the sum of the suppression of (2) and (5) (see legend of Figure 1/G.213) at the frequency of any received line-regulating pilot should therefore be at least 40 dB when the frequencies of these pilots are the same on both interconnected regulated-line sections. Division of this suppression between filters (2) and (5) may be made in different ways. As the two filters are in the same station this is not an international interconnection problem, but one of industrial standardization for countries which order systems from several manufacturers.

If it is considered necessary always to have a filter (5) before the point of injection of an outgoing line-regulating pilot, for the suppression of unwanted signals from other equipments, and if the line-regulating pilots of the two interconnected regulated-line sections are on the same frequency, the division may be made in the following way:

filter (2) = 20 dB
filter (5) = 20 dB.

Thus, if the frequencies of the pilots do not coincide and there is no interconnection with an international section, the 20 dB suppression recommended above will remain. Nevertheless, this provision may necessitate the addition of a further suppression at the adequate frequency at some point before reaching an international section.

To avoid the latter difficulty, it may be considered preferable, in order to facilitate network arrangements, to adopt the value of 40 dB for (2). If the frequencies of the pilots are the same on both interconnected regulated-line sections and if it has been considered desirable always to have a filter (5) before the point of injection of an outgoing line-regulating pilot, the suppression of the received line-regulating pilot will be very much greater than the recommended value of 40 dB. There is no technical objection to this.

5.2.2 *Additional measuring frequencies*

The additional measuring frequencies within the frequency band occupied by all the through-connected supergroups, etc., are normally transmitted without special blocking band may be affected by the sections of the through-connection filters.

There is no need in such cases for equipments to include methodical provision of blocking filters for protecting line-regulating pilots against additional measuring frequencies sent over a preceding section. The arrangements to be made by the maintenance staff when such blocking filters are not provided are shown in Recommendation M.500 [2].

References

[1] CCITT Recommendation *8-channel terminal equipments* , Orange Book, Vol. III-1, Rec. G.234, ITU, Geneva, 1977.

[2] CCITT Recommendation *Routine maintenance measurements to be made on regulated line sections* , Vol. IV, Rec. M.500.

Such special blocking attenuation would in any case be both expensive and technically difficult to achieve.

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