INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.792

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS

TERMINAL EQUIPMENTS

CHARACTERISTICS COMMON TO ALL TRANSMULTIPLEXING EQUIPMENTS

ITU-T Recommendation G.792

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.792 was published in Fascicle III.4 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation G.792

CHARACTERISTICS COMMON TO ALL TRANSMULTIPLEXING EQUIPMENTS

(Geneva, 1980; further amended)

The CCITT,

recommends

that the characteristics below be respected by all the transmultiplexing equipments defined in Recommendation G.791.

Recommendation O.133 contains information about test equipment. Account should be taken of the measurement accuracy provided by test equipment designed in accordance with that Recommendation.

The following specifications are based on ideal measuring equipment. Therefore, they do not include any margin for measurement errors.

To avoid level errors produced as a result of the use of test frequencies which are sub-multiples of the PCM sampling rate, the use of integer sub-multiples of 8 kHz should be avoided.

Where a nominal reference frequency of 1020 Hz is indicated (measurement of attenuation/frequency distortion and adjustment of relative levels), the actual frequency should be 1020, +2 to -7 Hz in accordance with Recommendation O.6 [18].

1 Coding law

Transmultiplexers should satisfy Recommendation G.711, § 3.

2 Sampling rate of PCM channels

The nominal sampling rate of PCM channels is 8000 Hz $\pm 50 \cdot 10^{-6}$ according to Recommendation G.711, § 2.

3 Amplitude limitation of PCM channels

In accordance with Recommendation G.711, § 4, the theoretical load capacity of PCM channel is + 3.14 dBm0 for the A-law and + 3.17 dBm0 for the μ-law.

4 Accuracy of the analogue virtual carriers

The analogue virtual carriers should satisfy the Recommendation cited in [1].

5 Saturation level at the input of the analogue group

The transmultiplexers should be able to accept at their analogue inputs, levels corresponding to the equivalent peak powers defined in Table 3/G.223 [5] (for example, + 19 dBm0 for a group and + 20.8 dBm0 for a supergroup).

Note - Attention is drawn to the possibility of using a transmultiplexer on the interpolated side of a digital speech interpolation (DSI) device. Given an interpolation rate of 2, this would lead to equivalent peak powers of 19.5 dBm0 for TMUX-P and 21.2 dBm0 for TMUX-S (see Table 3/G.223 [5]).

6 Methods of measuring quality in the audio band

The various possible methods of measuring quality characteristics in the audio band are indicated in Figure 1/G.792.

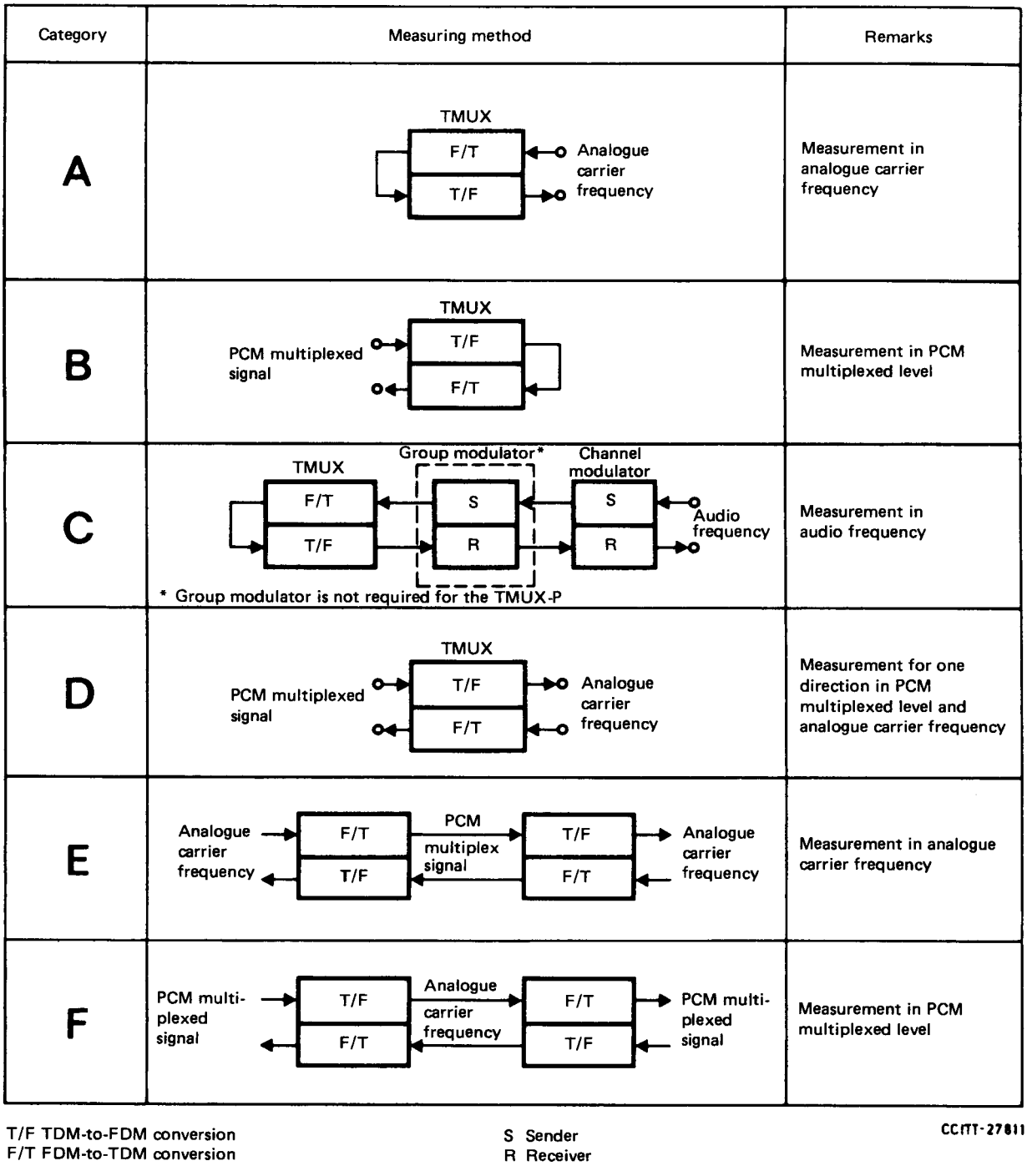


FIGURE 1/G.792

Block diagrams of measuring methods for transmultiplexers

When method B cannot be used because it requires digital signal generators and analyzers, which certain Administrations do not yet possess, method C can be used provisionally [looping of the digital ports, use of the terminals of auxiliary analogue channels (and possibly group modulators), assumption of the additivity of impairments and deduction of the impairments at the terminals of the channels (and possibly modulators) previously measured].

Method D corresponds in fact to four possible methods, depending on whether the emission of the test signal and its detection takes place on the analogue side or the digital side.

Methods E and F are used for crosstalk measurements.

For the sake of the convenience and precision of the measurements, it is desirable that the regulation, when included in the transmultiplexer, can be blocked with a gain equal to unity. The specifications in §§ 7 to 23 assume such blocking.

7 Attenuation distortion in the voice-frequency band as a function of frequency

The measuring method is method A.

The variation of the attenuation of each channel of a transmultiplexer as a function of frequency must remain within the limits of the mask in Figure 2/G.792. The level of emission is -10 dBm0; the reference frequency is 1020 Hz.

8 Group delay

8.1 *Absolute value of the group delay*

The measuring method is method A.

The absolute value of group delay defined as the minimum value of group delay in the speech band 300-3400 Hz should remain less than 3 ms for all the channels of a transmultiplexer.

Note - When the transmultiplexer is used for satellite digital communication at the earth station the minimum value of the group propagation time in the audiofrequency band may be increased from 3 ms to 6.5 ms. In all other cases, the value of 3 ms should be complied with.

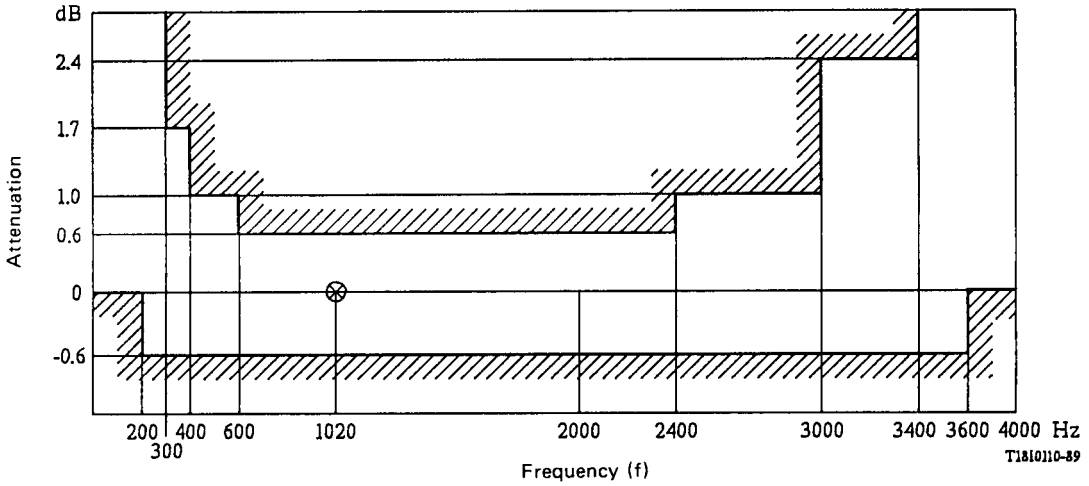


FIGURE 2/G.792

Attenuation distortion mask as a function of the frequency to be observed for all channels of a transmultiplexer

8.2 *Group-delay distortion*

The measuring method is method A.

The group-delay distortion should not exceed the limits of the mask in Figure 3/G.792.

The minimum group delay is taken as a reference; the power level at the input is 0 dBm0.

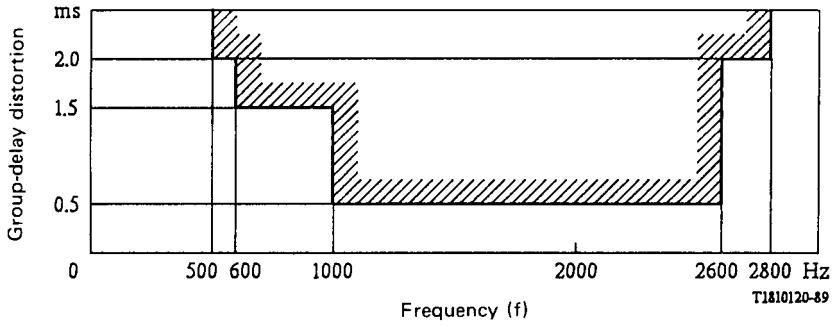


FIGURE 3/G.792
Mask of group-delay distortion as a function of frequency

9 Noise

9.1 *Idle channel noise, with all channels idle*

The measuring method is method B.

When a PCM signal corresponding to amplitude 0 for the μ-law and the number 1 for the A-law in all channels of the transmultiplexer is applied to the digital input of the transmultiplexer, the psophometric noise measured over any channel at the digital output should not exceed -65 dBm0p. The measurement is conducted in the presence of pilots.

9.2 *Channel noise, with all channels loaded except the one measured*

The measuring method is method A. In this case an intermodulation measuring set-up using the white noise method is employed, as described in the Recommendation cited in [6].

The level of emission of the noise signal being equal to the conventional load of the FDM signal considered (the Recommendation cited in [7]: 3.3 dBm0 for the group, 6.1 dBm0 for the supergroup), the noise measured in any given measuring slot should not exceed -62.5 dBm0p (i.e., -60 dBm0 in a 3100 Hz band).

The centre frequencies of the specified measuring slots (CCITT Recommendation G.230 [8] and CCIR Recommendation 482 [9]) applicable to the transmultiplexers are:

- for the base group: 70 and 98 kHz
- for the base supergroup: 394 and 534 kHz.

This measurement is carried out without emitting pilots or out-of-band signalling.

Note - Attention is drawn to the possibility of using a transmultiplexer on the interpolated side of a digital speech interpolation (DSI) device. Given an interpolation rate of 2, this would lead to conventional loads of 4.5 dBm0 for TMUX-P and 7.3 dBm0 for TMUX-S (see Table 2/G.223, [7]).

9.3 *Single frequency noise outside the band 300-3400 Hz*

The measuring method is B.

When a PCM signal corresponding to amplitude 0 for the μ-law and amplitude 1 for the A-law in all channels is applied to the digital input of the transmultiplexer, the noise over any frequency should not exceed -50 dBm0 with the exception of the frequency of 80 Hz where it should not exceed -40 dBm0.

9.4 *Idle noise in the PCM - FDM direction all channels idle*

The measuring method is method D. A PCM signal, amplitude 0 for the μ-law and 1 for the A-law is applied at the digital input of the transmultiplexer in all channels. The power of the noise measured at the analogue output in any channel must be less than -70 dBm0p.

Note - White noise is assumed, and to take account of the psophometric weighting, the measurement can be made in a band of 1740 Hz, centred on the odd multiples of 2 kHz. The measurement may be difficult in certain channels due to the presence of pilots.

10 Intermodulation

The measuring method is method A.

If two sine-wave signals of different frequencies f_1 and f_2 belonging to the band 300-3400 Hz of the channel considered, having no harmonic relation and of equivalent levels in the -4 to -21 dBm0 range, are applied simultaneously to the analogue ports of the transmultiplexer, there should be no intermodulation product of the type $2f_1 - f_2$ of a level higher than -35 dB with respect to the level of one of the two input signals.

11 Total distortion including quantizing distortion

The measuring method is method B (or provisionally method C).

If method B is used, the test signal is generated digitally and is therefore affected by theoretical quantizing distortion.

A choice between the two following methods is recommended:

Method 1

The signal-to-total distortion ratio measured according to method 1 described in § 8 of Recommendation G.712 should respect the mask of Figure 4/G.792. The mask is to be complied with by all channels of the transmultiplexer.

Method 2

With a sine-wave signal at a frequency between 700 and 1100 Hz or 350 and 550 Hz (e.g. 420 ± 20 Hz) (except for submultiples of 8 kHz) being applied in the channel concerned at the digital input of the transmultiplexer, the ratio of signal-to-total distortion power, measured with appropriate noise weighting (see the Recommendation cited in [10]), should be below the limits of the mask represented in Figure 5/G.792. The mask is to be complied with by all the channels of the transmultiplexer.

12 In-band spurious signals

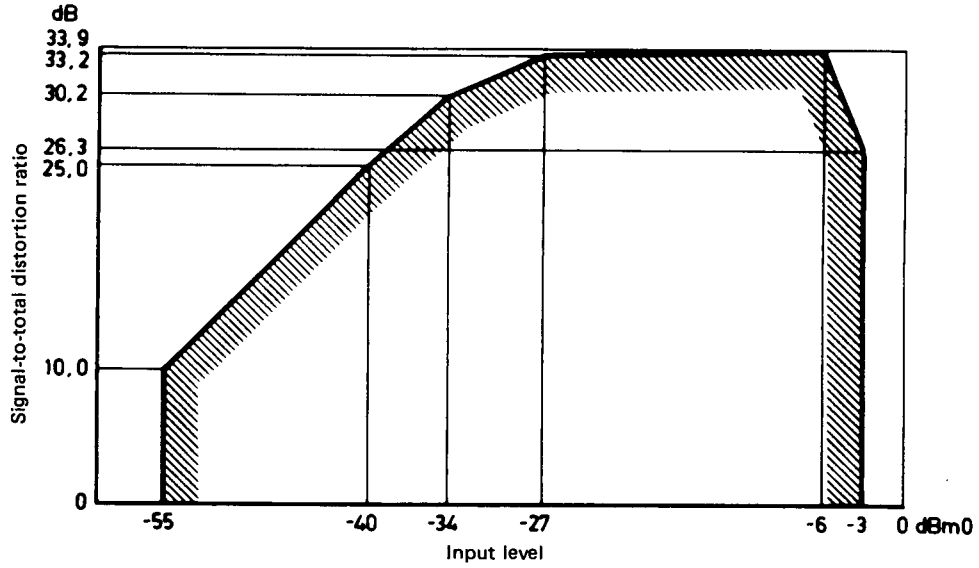
The measuring method is method A.

The transmultiplexers must meet the provisions of Recommendation G.712, § 9.

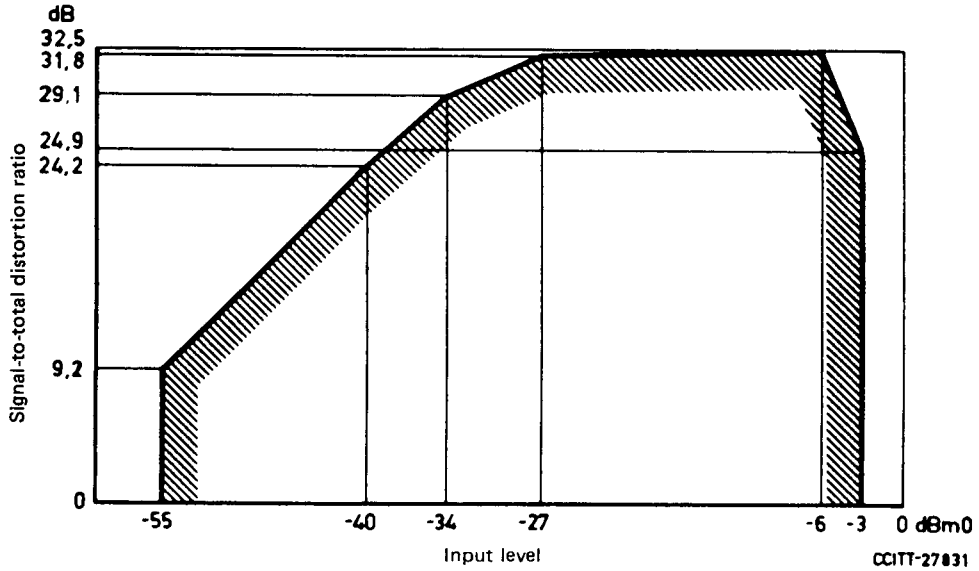
13 Variation of gain with the input level

The measuring method is method A, the pilots being present at the analogue input.

With a sine-wave signal at a frequency between 700 and 1100 Hz (except for submultiples of 8 kHz) and a level between -55 and +3 dBm0 being applied in the channel concerned at the analogue input of the transmultiplexer, the variation of gain with respect to its value for an input level of -10 dBm0 should remain between the limits of the mask shown in Figure 6/G.792. The mask is to be complied with by all channels of a transmultiplexer.



a) Method C



b) Method B

FIGURE 4/G.792

Signal-to-total distortion ratio as a function of the input level according to method 1 (Recommendation G.712, § 8)

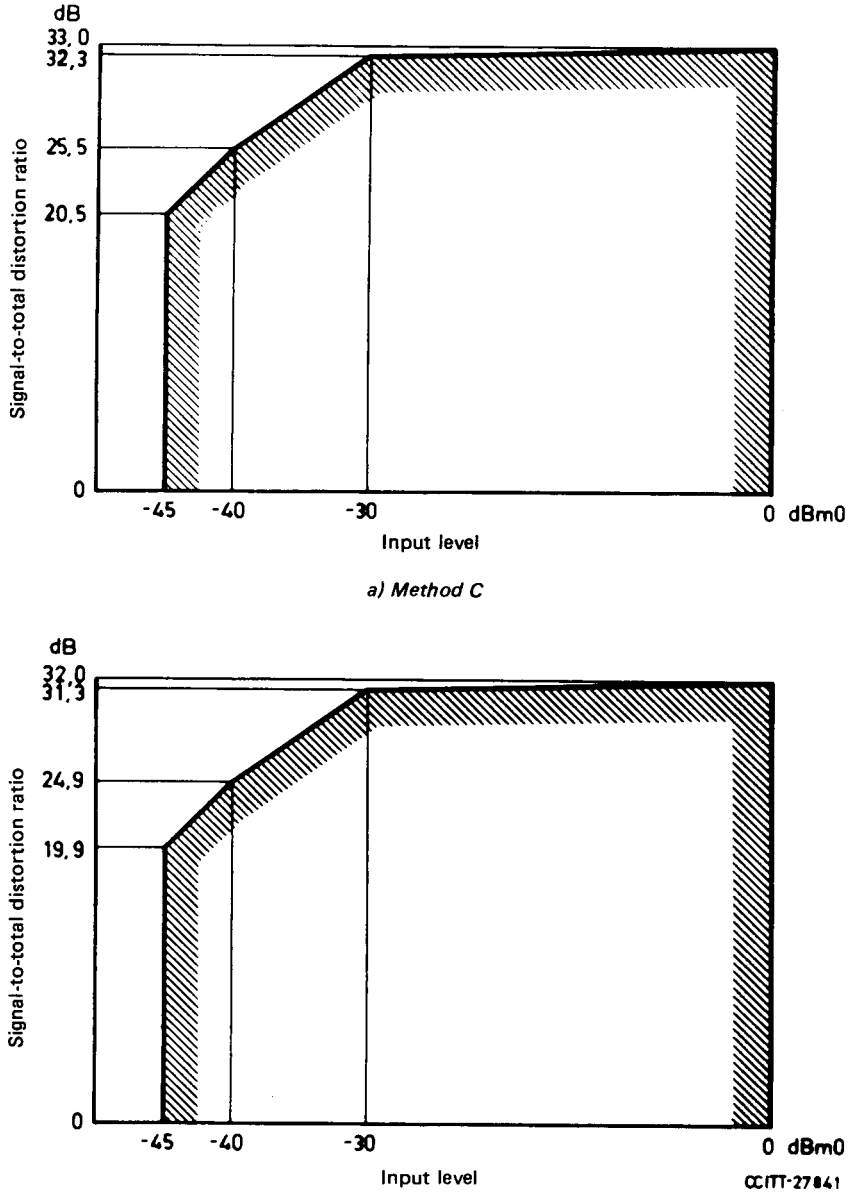


FIGURE 5/G.792

Signal-to-total distortion ratio as a function of the input level according to method 2 (Recommendation G.712, § 8)

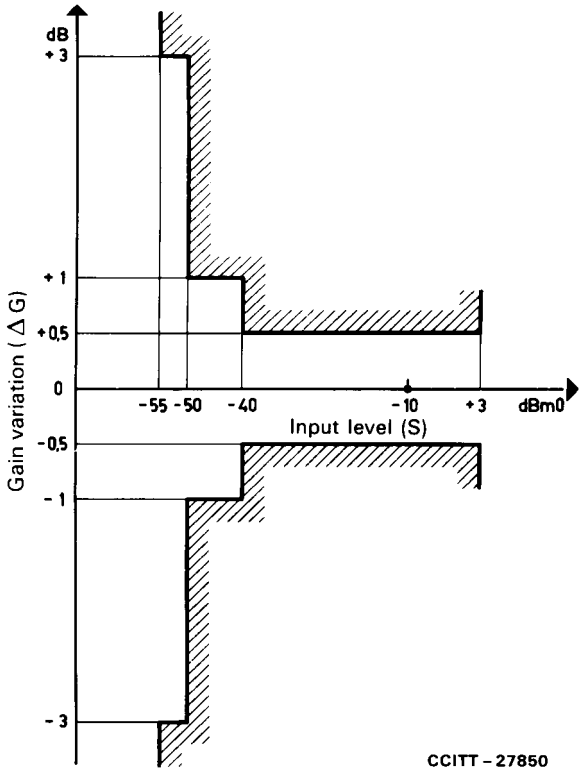


FIGURE 6/G.792

Gain variation as a function of input level S,
Method 2 in Recommendation G.712, § 10 (sinusoidal test signal)

14 Crosstalk

For measuring crosstalk, two transmultiplexers must be connected back-to-back (methods E and F). There are two possible configurations and four possible measurements (see Figure 7/G.792):

- far-end crosstalk digital to digital (see Note 1)
- near-end crosstalk digital to digital (see Note 1)
- far-end crosstalk analogue to analogue
- near-end crosstalk analogue to analogue

14.1 *Intelligible crosstalk*

When a sine-wave signal between 700 and 1100 Hz and with a level of 0 dBm0 is injected in any channel on the digital or analogue side of the transmultiplexer, the crosstalk ratio between the signal channel and any other channel must be greater than 65 dB for any of the four crosstalk contributions identified above (see Note 2).

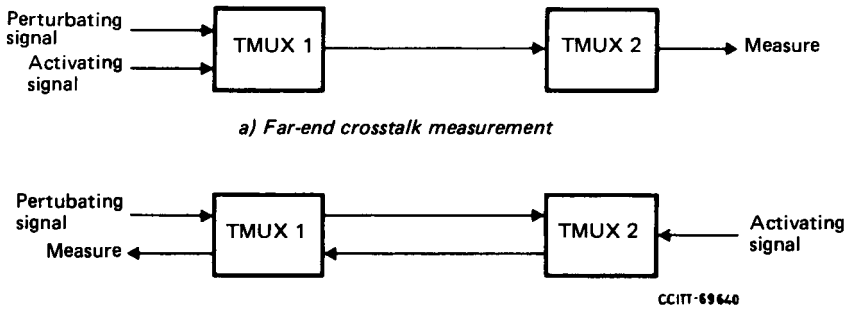
14.2 *Unintelligible crosstalk*

When a conventional telephone signal according to Recommendation G.227 [11] is injected in any channel on the digital or analogue side of the transmultiplexer, at a level of 0 dBm0, the level of crosstalk measured in any other channel for any of the four crosstalk contributions identified above must be below -60 dBm0p (see Note 3).

Note 1 - In this configuration, the two transmultiplexers are connected at the level of the analogue FDM signal and there will generally be a problem of level adaptation between the send and the receive sides. This can be solved with the use of attenuators or amplifiers of appropriate gain. Attention must be given on the risk of introduction of additional crosstalk in these complementary devices. It should be desirable to include the level adaptation facilities in the transmultiplexer itself.

Note 2 - In order to overcome fundamental gain enhancement effects associated with PCM encoders, which can mask the true crosstalk, measuring methods using activating signals based on those defined in Recommendation G.712 can be used.

Note 3 - Recognizing the difficulty of generating conventional telephone signals according to Recommendation G.227 in a suitable format for insertion into either the analogue or digital input to the transmultiplexer, it shall be adequate to demonstrate, via suitable single frequency crosstalk tests, that the intent of the above specification is met, without actually using a conventional telephone signal.



a) Far-end crosstalk measurement

b) Near-end crosstalk measurement

FIGURE 7/G.792

Measurements of crosstalk with methods E and F

15 Go-to-return crosstalk

For measuring go-to-return crosstalk, two transmultiplexers must be connected back-to-back (methods E and F). There are two possible configurations and two possible measurements (see Figure 7b/G.792):

- near-end crosstalk digital to digital (see Note 1 of § 14);
- near-end crosstalk analogue to analogue.

When a sine-wave signal between 300 and 3400 Hz and with a level of 0 dBm0 is injected in any channel on the digital or analogue side of the transmultiplexer, the crosstalk ratio between the signal channel and the associated return channel must be greater than 58 dB for each contribution identified above.

When using method F, a PCM signal corresponding to amplitude 0 for the μ-law and amplitude 1 for the A-law, should be inserted into the digital input of all return channels.

Note - Concerning the activating signal for method F, see Recommendation G.712, § 10.

16 Variation of the equivalent of the channels within the FDM assembly

Measuring method A.

When a test tone at the equivalent of 1020 Hz in any channel, and with a level of -10 dBm0 is applied to the analogue input of the transmultiplexer, the level measured at the analogue output of the transmultiplexer shall be within a tolerance of ± 1 dB of the level measured when that test tone is applied at the equivalent of 1020 Hz in the channel containing the reference pilot of the FDM assembly considered.

17 Adjustment of the relation between the coding law and the analogue level

Measuring method D.

To measure the correspondence between the coding laws and the analogue levels, the sequence of character signals from Table 5/G.711 for the A-law and from Table 6/G.711 for the μ-law may be applied periodically at the digital input of the transmultiplexer: the signal at the analogue output of the transmultiplexer should correspond to a sine-wave signal of frequency 1 kHz in the corresponding channel at a level between -0.5 and +0.5 dBm0.

Note - The use of another digital periodic sequence representing a nominal reference frequency of 1020 Hz at a nominal level of 0 dBm0 is acceptable, provided that the theoretical level accuracy is better than ± 0.03 dB.

To check the load capacity of the PCM coder contained in the transmultiplexer, a sine-wave signal at a nominal frequency of 1020 Hz can be applied for any channel at the analogue input of the transmultiplexer. Initially the level of this signal is considerably below the load capacity, then it is raised gradually. Note is taken of the input level at which the character signal corresponding to the extreme quantization interval for positive and negative amplitudes first appears at the digital output in the channel considered. The load capacity is then taken to be equal to this input level, increased by 0.3 dB. The values obtained for the various channels should be between 2.64 and 3.64 dBm0 for the A-law and between 2.67 and 3.67 dBm0 for the μ-law.

18 Carrier leak at the analogue ports

Measuring method A, the analogue input of the transmultiplexer being looped to its nominal impedance.

The transmultiplexers should meet the provisions of the Recommendation cited in [12].

19 Protection against out-of-band signals at the analogue ports

19.1 *Out-of-band spurious signals at the analogue output*

The measuring method is C for the TMUX-P, range a) (see below), otherwise A. The test signal has a level of 0 dBm0. For the TMUX-P, range a), a signal according to Recommendation G.227 is used, otherwise a sine-wave signal (300 to 3400 Hz). The level of supurious signals outside the group or supergroup band (f_1 to f_2) at the analogue output should not exceed the following limits:

TMUX-P a)	$f_1 > f_x > (f_1 - 4\ \text{kHz})$ and $f_2 < f_x < (f_2 + 4\ \text{kHz})$	⎫ ⎬ ⎭	≤ -60 dBm0p (Note 1)
b)	$(f_1 - 4\ \text{kHz}) > f_x > (f_1 - 12\ \text{kHz})$ } and $(f_2 + 4\ \text{kHz}) < f_x < (f_2 + 12\ \text{kHz})$	⎫ ⎬ ⎭	≤ -70 dBm0 (Note 2)
c)	$f_x \leq (f_1 - 12\ \text{kHz})$ and $f_x \geq (f_2 + 12\ \text{kHz})$	⎫ ⎬ ⎭	≤ -80 dBm0

TMUX-S a)	$f_x = f_1$ - 4 kHz and $f_x = f_2$ + 4 kHz	⎫ ⎬ ⎭	≤ -60 dBm0 (Note 3)
b)	$(f_1$ - 8 kHz) > f_x > (f_1 - 20 kHz) and (f_2 + 8 kHz) < f_x < (f_2 + 20 kHz)	⎫ ⎬ ⎭	≤ -70 dBm0 (Note 2)
c)	$f_x \leq (f_1$ - 20 kHz) and $f_x \geq (f_2$ + 20 kHz)	⎫ ⎬ ⎭	≤ -80 dBm0

Note 1 - Telephony channels, pilots or additional test frequencies are possible in this frequency range.

Note 2 - Adjacent carrier-frequency sound-programme channels may begin in this range (with reduced requirements).

Note 3 - This range may contain pilots or additional measuring frequencies.

19.2 *Crosstalk due to out-of-band signals at the analogue input*

Measuring methods C and A, respectively (see § 19.1). With test signals as in § 19.1 in a channel of an adjacent FDM assembly, the level at the transmultiplexer output should not exceed the following limits:

TMUX-P a)	$f_1 > f_x > (f_1$ - 4 kHz) and $f_2 < f_x < (f_2$ + 4 kHz)	⎫ ⎬ ⎭	≤ -60 dBm0p (Note)
b)	$f_x < (f_1$ - 4 kHz) and $f_x > (f_2$ + 4 kHz)	⎫ ⎬ ⎭	≤ -70 dBm0 (Note)
TMUX-S a)	$f_x = f_1$ - 4 kHz and $f_x = f_2$ + 4 kHz	⎫ ⎬ ⎭	≤ -50 dBm0 (Note)
b)	$f_x < (f_1$ - 8 kHz) and $f_x > (f_2$ + 8 kHz)	⎫ ⎬ ⎭	≤ -70 dBm0 (Note)

Note - For this measurement, a low-level auxiliary signal is injected into the disturbed channel. The appropriate auxiliary signal is a sine-wave signal between -33 and -40 dBm0. The frequency and characteristics of the filter in the measuring equipment must be carefully selected to ensure that the auxiliary signal does not appreciably reduce the accuracy of the crosstalk measurement.

20 Protection and suppression of pilots

Measuring method D.

The transmultiplexers should meet the provisions of the Recommendation cited in [14].

21 Protection and suppression of out-of-band signalling

21.1 *Protection of the out-of-band signalling channel for transmultiplexers using signalling system R2*

Measuring method D.

When a transmultiplexer is capable of emitting out-of-band signalling waves at frequency 3825 Hz, it should meet the provisions of Recommendation Q.414 [15], Figure 6/Q.414 being replaced by Figure 7/G.792. The measuring method associated with the latter figure is recalled in Note 1.

Note 1 - The signalling channel must be protected at the sending end against disturbance from the associated and the adjacent channel.

When a sine-wave at 0 dBm0 level is applied to the digital input of the associated channel, the level measured at the analogue output of the transmultiplexer must not exceed the levels shown in Figure 8/G.792.

When a sine-wave of frequency *f* is applied to the digital input of the adjacent channel, it produces two signals that appear on the frequency scale of Figure 8/G.792 as having the frequencies (4000 + *f*) and (4000 - *f*). The level of the (4000 + *f*) signal measured at the analogue output of the transmultiplexer shall not be higher than -33 dBm0, when the sine-wave with frequency *f* is applied to the digital input of the adjacent channel at a level shown in Figure 8/G.792 for the frequency of (4000 + *f*). The level of the (4000 - *f*) signal, measured at the analogue output of the transmultiplexer, shall not be higher than -33 dBm0, when the sine-wave with frequency *f* is applied to the digital input of the adjacent channel at any level below the value shown in Figure 8/G.792 for the frequency (4000 - *f*).

21.2 *Disturbance of telephone channels by out-of-band signalling frequency for transmultiplexers using signalling system R2*

The measuring method is method B or D.

Interference at 175 Hz and 3825 Hz should not exceed -53 dBm0 respectively -63 dBm0 when a continuous tone of 3825 Hz with a nominal level of -20 dBm0 is applied to all channels. These values correspond to a contribution to the channel noise in the order of -73 dBm0p (design objective).

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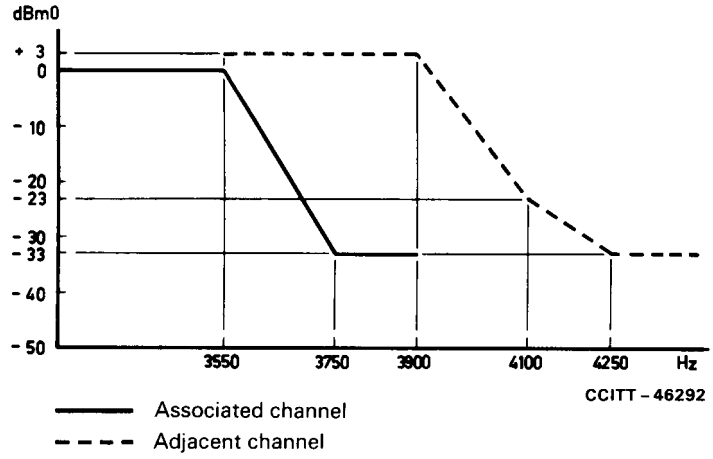

Note - The frequency of the virtual carrier of the associated speech channel is the origin of the frequency scale (zero frequency)

FIGURE 8/G.792

Protection of the signalling channel at the sending end

21.3 *Other out-of-band signalling systems*

See Annex A.

22 Mutual interference between pilots and out-of-band signalling

The transmultiplexers capable of emitting and receiving out-of-band signalling should meet the provisions of the Recommendation cited in [17].

23 Short- and long-term variation of loss with time

The measuring method is A. When a sine-wave signal at level -10 dBm0 and at a nominal frequency of 1020 Hz is applied at the analogue input of the transmultiplexer, the level measured at the analogue output should not vary by more than ± 0.2 dB during 10 consecutive minutes of normal operation, more than ± 0.5 dB during 3 consecutive days nor by more than ± 1 dB for one year, allowing for the authorized variations of power supply, voltages and temperature.

ANNEX A

(to Recommendation G.792)

Out-of-band signalling systems using a burst-mode method

The possibility of such systems is mentioned in Annex A to Recommendation Q.21 and Annex B to Recommendation G.232. These annexes should be taken into consideration. When a transmultiplexer is capable of converting such systems, the following applies:

- Signalling frequency at the sending point: 3825 Hz ± 4 Hz.
- Send level of the signalling frequency: -5 dBm0 ± 1 dB.
- Protection of the out-of-band signalling channel: see Figure 8/G.792.

- Disturbance of telephone channels by the out-of-band signalling frequency: the measuring method is method B.
- Channel noise should not exceed -63 dBm0p in the call channel (continuous tone).
- In the adjacent channel (the closest to the signalling frequency) likewise -63 dBm0p burst or continuous tone.
- In every other channel -76 dBm0p burst or continuous tone.

Note 1 - Burst tones do not occur in the call channel after call set-up has taken place.

Note 2 - Burst rates are in the order of 10 to 25 Hz.

Note 3 - Charge metering pulses are of long duration, e.g. 150/450 ms and are evaluated as a continuous tone.

References

[1] CCITT Recommendation *Recommendations relating to the accuracy of carrier frequencies*, Vol. III, Rec. G.225, § 1.

[2] CCITT Recommendation *Pilots on groups, supergroups, etc.*, Vol. III, Rec. G.241, § 1.

[3] *Ibid.*, § 2.

[4] *Ibid.*, § 3.

[5] CCITT Recommendation *Assumptions for the calculation of noise on hypothetical reference circuits for telephony*, Vol. III, Rec. G.223, Table 3/G.223, § 6.

[6] CCITT Recommendation *Measurement of circuit noise in cable systems using a uniform-spectrum random noise loading*, Vol. III, Rec. G.228, §§ A.1, A.2.2.

[7] CCITT Recommendation *Assumptions for the calculation of noise on hypothetical reference circuits for telephony*, Vol. III, Rec. G.223, § 2.1.

[8] CCITT Recommendation *Measuring method and through-connection filters for noise produced by modulating equipment*, Vol. III, Rec. G.230.

[9] CCIR Recommendation *Measurement of performance by means of a signal of a uniform spectrum for systems using frequency-division multiplex telephony in the fixed satellite service*, Vol. IV, Rec. 482, ITU, Geneva, 1978.

[10] CCITT Recommendation *Assumptions for the calculation of noise on hypothetical reference circuits for telephony*, Vol. III, Rec. G.223, § 7.

[11] CCITT Recommendation *Conventional telephone signal*, Vol. III, Rec. G.227.

[12] CCITT Recommendation *12-channel terminal equipments*, Vol. III, Rec. G.232, §§ 5.1, 5.2.

[13] CCITT Recommendation *Through-connection of groups, supergroups, etc*., Vol. III, Rec. G.242, § 1.

[14] CCITT Recommendation *12-channel terminal equipments*, Vol. III, Rec. G.232, §§ 12.1, 12.2 and Annex A.

[15] CCITT Recommendation *Signal sender*, Vol. VI, Rec. Q.414, Figure 6/Q.414.

[16] CCITT Recommendation *12-channel terminal equipments*, Vol. III, Rec. G.232.

[17] *Ibid.*, § 12.3 and Annex B.

[18] CCITT Recommendation *1020 Hz reference test frequency*, Vol. IV, Rec. O.6.