5i’

7.9 Other terminal equipments

Recommendation G.791

GENERAL CONSIDERATIONS ON TRANSMULTIPLEXING EQUIPMENTS

(Geneva, 1980; further amended)

The CCITT,

considering

the advantages offered in some cases by direct through-connection (without voice-frequency interfaces) from FDM signals to TDM signals and vice versa,

recommends in such cases

(1) the use of the transmultiplexing equipment described in Definition 4020 of Recommendation G.701;

(2) Recommendation G.792 which contains the characteristics common to all transmultiplexing equipment;

(3) Recommendation G.793 which concerns 60-channel transmultiplexers providing 2048 kbit/s signals and using A-law encoding;

(4) Recommendation G.794 which concerns 24-channel transmultiplexers providing 1544 kbit/s signals and using μ-law encoding.

1 Complementary definitions

1.1 type P transmultiplexer (TMUX-P)

A transmultiplexing equipment in which the analogue interface is made up of several groups.

1.2 type S transmultiplexer (TMUX-S)

A transmultiplexing equipment in which the analogue interface is made up of one or more supergroups.

1.3 hierarchical transmultiplexer

A transmultiplexer in which the digital interfaces satisfy the provisions of Recommendations G.703 and G.704 and the analogue interfaces those of Recommendation G.233 [1].

1.4 **transmultiplexer channel**

A frequency band of 4000 Hz on the analogue side, corresponding to a bit rate of 64 kbit/s on the digital side, which permits the transmission of a signal limited to the telephone band 300-3400 Hz. Access may be gained to a given channel:

— either at the level of the time slot associated with the relevant channel of the TDM signal;

— or at the level of the frequency band (f_p, $f_p \pm$ | 000 Hz) of the FDM signal, f_p being the virtual carrier frequency associated with the channel concerned. The + sign corresponds to the case of the base supergroup, the — sign to the case of the base group.

Note — Correspondence between out-of-band signalling on the analogue side and channel associated signalling on the digital side will be covered in the Recommendations specific to the various transmultiplexers.

2 Transmultiplexer application

The application on transmultiplexers for the interconnection of digital and analogue networks is illustrated in Supplement No. 28.

Reference

[1] CCITT Recommendation *Recommendations concerning translating equipments* , Vol. III, Rec. G.233.

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 ± | 0 × 10^{D}lF261^{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 p. 1

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 p. 2

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, p.

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.

figure 4/G.792 p. 4

figure 5/G.792 p. 4

figure 6/G.792 p. 6

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.

Figure 7/G.972, p.

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 ± | 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 dBmO is acceptable, provided that the theoretical level accuracy is better than ± | .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 kHz) —60 dBm0p

and

$f_2 < f_x < (f_2$ + 4 kHz) (Note 1)

b) (f_1 — 4 kHz) > f_x > (f_1 — 12 kHz) —70 dBm0

and

(f_2 + 4 kHz) < f_x < (f_2 + 12 kHz) (Note 2)

c) f_x (f_1 — 12 kHz)

and —80 dBm0

f_x ≥" (f_2 + 12 kHz)

TMUX-S a) $f_x = f_1$ — 4 kHz —60 dBm0

and

$f_x = f_2$ + 4 kHz (Note 3)

b) (f_1 — 8 kHz) > f_x > (f_1 — 20 kHz) —70 dBm0

and

(f_2 + 8 kHz) < f_x < (f_2 + 20 kHz) (Note 2)

c) f_x (f_1 — 20 kHz)

and —80 dBm0

f_x ≥" (f_2 + 20 kHz)

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) $f_1 > f_x > (f_1 — 4\text{ kHz})$ —60 dBm0p

and

$f_2 < f_x < (f_2 + 4\text{ kHz})$ (Note)

b) $f_x < (f_1 — 4\text{ kHz})$ —70 dBm0

and

$f_x > (f_2 + 4\text{ kHz})$ (Note)

TMUX-S a) $f_x = f_1 — 4\text{ kHz}$ —50 dBm0

and

$f_x = f_2 + 4\text{ kHz}$ (Note)

b) $f_x < (f_1 — 8\text{ kHz})$ —70 dBm0

and

$f_x > (f_2 + 8\text{ kHz})$ (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).

Figure 8/G.792, p.

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 ± | .2 dB during 10 consecutive minutes of normal operation, more than ± | .5 dB during 3 consecutive days nor by more than ± | 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.

Recommendation G.793

CHARACTERISTICS OF 60-CHANNEL TRANSMULTIPLEXING EQUIPMENTS

(Geneva, 1980; further amended)

1 Introduction

The 60-channel transmultiplexer is a transmultiplexing equipment which satisfies Recommendations G.791 and G.792 and provides interconnection between two digital signals at 2048 kbit/s and an analogue supergroup (60-channel TMUX-S).

2 Digital interfaces

2.1 *Coding law*

The coding law used is A-law specified in Recommendation G.711.

2.2 *Interfaces*

The 2048-kbit/s interfaces satisfy Recommendation G.703, § 6.

2.3 *Frame structure*

The structure is specified in Recommendation G.704, § 3.3.1.

The strategy and the criteria for loss and recovery of frame alignment satisfy Recommendation G.706, § 4.1.

2.4 *Multiframe structure*

The multiframe structure of time slot 16 satisfies Recommendation G.704, § 3.3.3.

The strategy and the criteria for loss and recovery of multiframe alignment satisfy Recommendation G.732, § 5.2.

3 Analogue interfaces

3.1 *Ports*

The analogue interface consists of a 60-channel supergroup (band 312-552 kHz) which satisfies Recommendation G.233 [1].

The preferred signal levels at the supergroup distribution frame should be:

— for sending —36 dBr

— for receiving —30 dBr

The impedances are: 75 ohms (unbalanced).

3.2 *Pilots*

The 60-channel transmultiplexer should transmit the following pilots:

TMUX-S: A supergroup pilot with a frequency 411 | 20 Hz and a level of —20 dBm0,

one pilot per group with a level of —20 dBm0 and frequencies of:

Group 1: 335 | 20 Hz

Group 2: 383 | 20 Hz

Group 3: 431 | 20 Hz

Group 4: 479 | 20 Hz

Group 5: 527 | 20 Hz

The transfer of pilot alarms individually for each group in a supergroup and the consequence for the split channels of group 3 can be seen in Figure 1 of Supplement No. 32.

Other sets of pilots as recommended in Recommendation G.241 can be used. Special attention should be given to the compatibility of the set of pilots adopted with the out-of-band signalling system using a frequency at 3825 Hz.

The characteristics relating to the generation and transmission of these pilots are given in Recommendation G.241 [2].

3.3 *Pilot detection and regulation*

The transmultiplexer may or may not regulate levels on the basis of the levels of the group and supergroup pilots. If so, the transmultiplexer must meet the conditions of the Recommendation cited in [2]. Detection of the levels of the group pilots and or supergroup mentioned in § 3.2 should, however, be effected to ensure operation of the interruption control system (Recommendation Q.416 [3]), when R2 signalling is used.

4 Correspondence between analogue and digital channels

A fixed correspondence is established between the analogue and digital channels. The correspondence shown in Table 1/G.793 (which facilitates the transfer of alarms and results in a natural order of the channels on the analogue side) is recommended.

H.T. [T1.793]

TABLE 1/G.793

PCM 1 channels 1 to 12	Group 1 312-360 kHz
PCM 1 channels 13 to 24	Group 2 360-408 kHz
PCM 1 channels 25 to 30	Group 3 408-432 kHz
PCM 2 channels 1 to 6	Group 3 432-456 kHz
PCM 2 channels 7 to 18	Group 4 456-504 kHz
PCM 2 channels 19 to 30 Group 5 504-552 kHz }	{

Note — In national networks or by agreement between Administrations, other schemes of correspondence between analogue and digital channels may be used.

Table 1/G.793 [T1.793], p.

5 Plesiochronous operation of incoming PCM streams

Sixty-channel transmultiplexers should be able to accept two mutually plesiochronous incoming PCM streams within the limits laid down in Recommendation G.703 (bit rate 2048 kbit/s, ± | 0 | (mu | 0^{D}lF261^{6}).

In the case of transmultiplexers with digital filtering, this means that the two input ports at 2048 kbit/s are fitted with frame aligners (jump or repetition of samples) and multiframe aligners for synchronizing the incoming PCM streams with the transmultiplexer clock. In order to avoid a major slip frequency, the two incoming PCM streams should be either synchronous with the transmultiplexer or plesiochronous with each other and with the transmultiplexer clock, so that Recommendation G.811 on the plesiochronous network is satisfied.

6 Synchronization of transmultiplexer

The transmultiplexer must produce virtual analogue carrier frequencies with the accuracy specified in Recommendation G.225 [4] (± | 0^{D}lF261^{7}).

For this purpose, it is recommended:

a) either that the transmultiplexer should have an internal clock of sufficient accuracy;

b) or that the transmultiplexer should be synchronizable with an external signal which may be:

1) a frequency (see Note 3) produced by a central FDM generator: 4, 12 or 124 kHz;

2) or one of the incoming PCM streams which has sufficient accuracy (this may be the case, for example, when this PCM stream at 2048 kbit/s is produced by a TDM switching equipment). If both 2048-kbit/s streams are of sufficient accuracy, the use of PCM stream No. 1 is preferred. In most cases this avoids, at the digital filtering transmultiplexer input, the slipping phenomena which, when too frequent, cause high error rates on in-band data signals.

Note 1 — In the case of a digital filtering transmultiplexer, when synchronization on one of the incoming PCM streams is not possible, the remote digital terminal should have the sending side synchronized with the receiving side so as to avoid slipping at the transmultiplexer input.

Note 2 — In the case of external synchronization, transmultiplexers often have an internal oscillator locked to the external signal. If, upon loss of the external sync signal, this internal oscillator is allowed to continue to supply the clock for the outgoing digital signal (now in the free-running mode), then this oscillator should have a minimum free-running accuracy of 50×10^{D}lF261^{6}. This is intended to allow the distant end digital terminal to receive an adequate frequency for alarm purposes only, so as not to confuse maintenance and trouble-shooting activities. Also, a local alarm should be given in the event of a fault in the synchronization system or in the absence of the external synchronization signal (Tables 2/G.793, 3/G.793 and 2 of Supplement No. 32).

Note 3 — In the case where the transmultiplexer is to be used in a TDMA satellite application, the effect of the satellite Doppler frequency variation must be taken into account. This can be done in two ways:

— either, the TDMA terminal incorporates the Doppler buffer memories of appropriate capacity in the earth station to satellite direction. In this case, the two directions of the TMUX must be synchronized from one of the two 2048 kbit/s PCM streams transmitted by the TDMA receive terminal;

— or, the TDMA terminal does not incorporate Doppler buffers. In this case, the PCM to FDM direction of the TMUX may be synchronized from one of the two 2048 kbit/s streams transmitted by the TDMA receive terminal. In the FDM to PCM direction, the 2048 kbit/s streams transmitted by the TMUX must be made synchronous with the TDMA system transmit clock: this supposes that a synchronization signal (contradirectional with the data) is provided by the TDMA transmit terminal to the TMUX. In the case where the processing in a digital filtering transmultiplexer is made synchronously for the two directions, Doppler buffer memories of appropriate capacity must be incorporated in the PCM interfaces.

7 Signalling

Different kinds of signalling systems can be envisaged.

7.1 *In-band signalling*

The 60-channel transmultiplexer is transparent for channel-associated in-band signalling.

7.2 *Common channel signalling*

In the case when common channel signalling must be routed through the transmultiplexer, attention is drawn to the fact that the transmission capabilities of a channel in the transmultiplexer is limited to the band 300-3400 Hz (i.e. data rates corresponding to this frequency band). Information on signalling bit rates is given in § 2 of Recommendation Q.702.

In the opposite case, when common channel signalling is not routed through the TMUX, no special problems are recognized.

7.3 *Out-of-band signalling*

As regards Signalling System R2, signalling conversion between the analogue and digital versions of line signalling as recommended in Recommendation Q.430 is to be used in the case of international interconnection and should conform to the following specifications.

The transmultiplexer, or an additional equipment associated with it, converts the analogue version to the 2-bit digital version of the R2 line Signalling System, and vice versa. In all cases, the transmultiplexer should provide the following facilities for signalling:

a) *Analogue side*

1) recognition of the signalling frequency at 3825 Hz in accordance with Recommendation Q.415 [5];

2) transmission of the signalling frequency at 3825 Hz in accordance with Recommendation Q.414 [6];

3) supervision of group pilots (and supergroup pilots if necessary) in accordance with Recommendation Q.416 [3].

b) *Digital side*

1) extraction of signalling bits *a* and *b* of time slots 16 received in accordance with the Recommendation cited in [7];

2) insertion of appropriate signalling data in bits *a* and *b* of time slots 16 transmitted in accordance with the Recommendation cited in [7];

3) detection of PCM system faults.

The conversion between the analogue and digital versions of the R2 line Signalling System should be made in accordance with [8]. When the conversion is made in an external equipment, the transmultiplexer should supply the necessary ports.

For national networks, a method of using the analogue line signalling version on both analogue and digital transmission systems is described in Supplement No. 32.

8 Fault conditions and consequent action

8.1 *Principles of the action to be taken*

The principles governing the handling of alarms is as follows: The behaviour of a transmultiplexer vis-`a-vis a 30-channel PCM multiplex should be the same as that of another 30-channel PCM multiplex. However, the transmultiplexer performs certain functions peculiar to digital multiplexing equipments such as the transmission of the Alarm Indication Signal (AIS). Vis-`a-vis a group modulator, it should behave like another group modulator.

The principles of alarm transfer are described in Supplement No. 32 which also contains particular solution used in national networks.

8.2 *Digital version of R2 signalling system*

Table 2/G.793 summarizes the fault conditions and the consequent actions.

8.3 *In-band signalling and common channel signalling*

Table 3/G.793 summarizes the fault conditions and the consequent actions (see Note).

Note — The problem of per channel alarm transfer needs further study. For applications where the TMUX is used in TDMA configuration, Recommendation Q.33 should be considered [11].

Blanc

H.T. [1T2.793]

TABLE 2/G.793
{
Fault conditions and consequent actions, applicable if Signalling System R2 is used
(see Note 1)
}

Fault conditions	Consequent actions			
	{			
Loss of signal Error ratio > 10^{-3} Loss of frame alignment (see Note 2) }	Yes (see Note 3)	Yes	Yes PCM > FDM	a=b=1

{
Loss of multiframe alignment
(see Note 2)
}
	Yes (see Note 3)		Yes	

{
Reception of bit 3, time slot 0 or bit 6, time slot 16, frame 0
(see Note 2)
}
{
Absence of the received group pilot
(see Note 5)
}
	Yes	Yes FDM > PCM	Absence of pilot	Yes (see Note 6

{
Absence of the received supergroup pilot
(see Note 7)
}
	Yes			

{
Pilot level deviation alarm (Note 8)
}
	Yes			

	Failure of power supply	Yes	Yes, if possible	Yes, if possible
	System failure (see Note 9)	Yes	Yes	Yes (see Note 6
Synchronization failure (see Note 10) }	{ Yes			

Note 1 — A *Yes* in the table signifies that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Pour Montage : System alarms FDM alarms PCM alarms

Table 2/G.793 [1T2.793] (a l'italienne), p.

H.T. [2T2.793]

Note 2 — The fault conditions ‘‘Loss of signal at 2 Mbit/s’’, ‘‘Error ratio > 10^{D}lF261^{3},’’, ‘‘Loss of frame alignment’’, ‘‘Loss of multiframe alignment’’, ‘‘Reception of bit 3, time slot 0’’, ‘‘Reception of bit 6, time slot 16, frame 0’’ and the consequent action ‘‘Bit 3, time slot 0 to 1’’, ‘‘Bit 6, time slot 16, frame 0 to 1’’, ‘‘Bit 6, time slot 16, frame 0 to 1’’ and ‘‘AIS sent’’ are defined in Recommendation G.732.

Note 3 — The 60-channel transmultiplexer should be able to detect the alarm indication signal (AIS) on incoming streams at 2048 kbit/s. When AIS is detected, the prompt maintenance indication associated with the loss of frame alignment, with an excessive error rate or with the loss of multiframe alignment should be blocked.

Note 4 — This action is not necessary when the digital version of Signalling System R2 is used, but may be useful with other applications.

Note 5 — The definition of absence of group pilot used for the operation of the interruption control system is given in the Recommendation cited in [9]. The supergroup pilot can also be used.

Note 6 — The AIS is sent only if the 30 channels of a single PCM stream are in the alarm condition.

Note 7 — Detection of ‘‘absence of supergroup pilot’’ is not obligatory. If the supergroup pilot is not sent, this alarm function can be performed by supervision of the 5 group pilots.

Note 8 — The concept of pilot level deviation alarm corresponds to a variation on the level of the pilot from its nominal value by more than ± | dB, as stated in [10]. This applies only to transmultiplexers with automatic internal level regulation.

Note 9 — The ‘‘system’’ fault condition corresponds to a fault on the transmultiplexer detected by the transmultiplexer’s supervision system, when it has one.

Note 10

— The ‘‘synchronization’’ fault is that mentionned in § 6 of Recommendation G.793. When the transmultiplexer is synchronized with an external signal or with one of two incoming PCM streams at 2048 kbit/s, the transmultiplexer should transmit an alarm signal in the event of synchronization loss.

H.T. [1T3.793]

TABLE 3/G.793

Fault conditions and consequent actions, applicable for in-band signalling and common channel signalling

(Note 1)

Fault conditions	Consequent actions					
	{					
Loss of signal Error ratio > 10^{-3} Loss of frame alignment (see Note 2) }	{ Yes (see Note 3)	Yes	Yes PCM | > | DM	Yes (see Note 4)		
Absence of the received group pilot (see Note 5) } Absence of the received supergroup pilot (see Note 7) }	{ Yes	Yes FDM | > | CM	Yes (see Note 6)		{	
Yes Pilot level deviation alarm (see Note 8) }	{ Yes					
	Failure of power supply	Yes	Yes, if possible	Yes, if possible		System
Yes Synchronization failure (see Note 10) }	Yes, 5 groups Yes	Yes (see Note 7)		{		

Note 1 — A *Yes* in the table signifies that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should not be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — The fault conditions ‘‘Loss of signal at 2 Mbit/s’’, ‘‘Error ratio > 10^{-3},’’, ‘‘Loss of frame alignment’’, and the consequent action ‘‘Bit 3, time slot 0 to 1’’, and ‘‘AIS sent’’ are defined in Recommendation G.732.

Note 3 — The 60-channel transmultiplexer should be able to detect the alarm indication signal (AIS) on incoming streams at 2048 kbit/s. When AIS is detected, the prompt maintenance indication associated with the loss of frame alignment, with an excessive error rate should be blocked.

Note 4 — In the PCM FDM direction, the pilots must be cut for the 3 groups associated with a PCM multiplex signal in the event of the detection of a fault on the PCM multiplex signal stream. When a single PCM multiplex signal is faulty, this involves the blocking of 6 channels which are not faulty.

Note 5 — The definition of absence of group pilot used for the operation of the interruption control system is given in the Recommendation cited in [9]. The supergroup pilot can also be used.

Note 6 — The AIS is sent only if the 30 channels of a single PCM stream are in the alarm condition.

Note 7 — Detection of ‘‘absence of supergroup pilot’’ is not obligatory. If the supergroup pilot is not sent, this alarm function can be performed by supervision of the 5 group pilots.

Pour Montage : System alarms IDM alarms PCM alarms

Notes of the Table 2/G.793 [2T2.973], p.

H.T. [1T3.793]

TABLE 3/G.793

Fault conditions and consequent actions, applicable for in-band signalling and common channel signalling

(Note 1)

Fault conditions	Consequent actions					
	{					
Loss of signal Error ratio > 10^{D}lF261^{3} Loss of frame alignment (see Note 2) }	Yes (see Note 3)	Yes	Yes PCM | > | DM	Yes (see Note 4)		
Absence of the received group pilot (see Note 5) } Absence of the received supergroup pilot (see Note 7) }	{ Yes	Yes FDM | > | CM	Yes (see Note 6)		{	
Yes Pilot level deviation alarm (see Note 8) }	{ Yes					
	Failure of power supply	Yes	Yes, if possible	Yes, if possible		System
Yes Synchronization failure (see Note 10) }	Yes, 5 groups Yes	Yes (see Note 7)		{		

Note 1 — A *Yes* in the table signifies that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should not be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — The fault conditions ''Loss of signal at 2 Mbit/s'', ''Error ratio > 10^{D}lF261^{3},'', ''Loss of frame alignment'', and the consequent action ''Bit 3, time slot 0 to 1'', and ''AIS sent'' are defined in Recommendation G.732.

Note 3 — The 60-channel transmultiplexer should be able to detect the alarm indication signal (AIS) on incoming streams at 2048 kbit/s. When AIS is detected, the prompt maintenance indication associated with the loss of frame alignment, with an excessive error rate should be blocked.

Note 4 — In the PCM FDM direction, the pilots must be cut for the 3 groups associated with a PCM multiplex signal in the event of the detection of a fault on the PCM multiplex signal stream. When a single PCM multiplex signal is faulty, this involves the blocking of 6 channels which are not faulty.

Note 5 — The definition of absence of group pilot used for the operation of the interruption control system is given in the Recommendation cited in [9]. The supergroup pilot can also be used.

Note 6 — The AIS is sent only if the 30 channels of a single PCM stream are in the alarm condition.

Note 7 — Detection of ‘‘absence of supergroup pilot’’ is not obligatory. If the supergroup pilot is not sent, this alarm function can be performed by supervision of the 5 group pilots.

Pour Montage : System alarms IDM alarms PCM alarms

Table 3/G.793 [1T3.793], p.

H.T. [2T3.793]

Note 8 — The concept of pilot level deviation alarm corresponds to a variation on the level of the pilot from its nominal value by more than ± | dB as stated in the Recommendation cited in [10]. This applies only to transmultiplexers with automatic internal level regulation.

Note 9 — The ‘‘system’’ fault condition corresponds to a fault on the transmultiplexer detected by the transmultiplexer’s supervision system, when it has one.

Note 10 — The ‘‘synchronization’’ fault is that mentionned in § 6 of the Recommendation G.793. When the transmultiplexer is synchronized with an external signal or with one of the two incoming PCM streams at 2048 kbit/s, the transmultiplexer should transmit an alarm signal in the event of synchronization loss.

Pour Montage : System alarms IDM alarms PCM alarms

H.T. [1T1.794]

TABLE 1/G.794

Fault conditions and consequent action for the 24-channel transmultiplexer

{
Consequent
Action
Fault Conditions
}
	{
	Prompt maintenance alarm indication (7)
	}
		{
		Alarm indication to the remote equipment (3)
		}
			AIS sending (4)
			Blocking of faulty speech channels
			}
				{
				Pilot cut-off
				to the remote
				FDM terminal
				}	

{
Loss of frame alignment and multiframe alignment or
Loss of incoming signal (2)
}
Digital error
ratio 10^{D}lF261^{4}
or 10^{D}lF261^{3} (10)
}
	{
	Yes (8)
		Yes	Yes (PCM | > | DM)		

Yes (8) Reception of alarm indication from the remote equipment (2, 3) }	Yes Yes		{ AIS receiving (4)		
Yes	Yes (PCM | | > | DM)				
Pilot level deviation alarm (11) }	Absence of group pilot (5)	Yes	Yes (9)	Yes	
Yes, if regulation is present					
Yes, depending on network applications }	Failure of power supply (2)	Yes System failure (6)	{ Yes		

{
Yes, depending
on network
applications
}
Yes, depending
on network
applications
}
Yes, depending
on network
applications
}
Yes, depending
on network
applications
}
	{
	{
	{
		Synchronization failure	Yes		

Note 1 — A *Yes* in the table signifies that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should not be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — The fault conditions ‘‘Loss of incoming signal’’, ‘‘Loss of frame alignment and multiframe alignment’’, ‘‘Reception of alarm indication to the remote equipment’’ and ‘‘Failure of power supply’’ are defined in Recommendation G.733.

Note 3 — For ‘‘Alarm indication to the remote equipment’’, data link bits are used.

Note 4 — The AIS can be used only in the new frame structure to be specified by Study Group XVIII.

Note 5 — The level, at which ‘‘Absence of group pilot’’ is detected, is under study.

Note 6 — The ‘‘System failure’’, which is only for the digital filtering transmultiplexer, corresponds to a fault detected by the transmultiplexer’s supervision system, when it has one.

Note 7 — The consequent action ‘‘Prompt maintenance Alarm indication’’ and ‘‘Alarm indication to the remote equipment’’ are defined in Recommendation G.733.

Notes of the Table 3/G.793 [2T3.793], p.

References

[1] CCITT Recommendation *Recommendations concerning translating equipments* , Vol. III, Rec. G.233.

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

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

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

[5] CCITT Recommendation *Signal receiver* , Vol. VI, Rec. Q.415.

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

[7] CCITT Recommendation *Digital line signalling code* , Vol. VI, Rec. Q.421, § 3.1.2.

[8] CCITT Recommendation *Conversion between analogue and digital versions of system R2 line signalling* , Vol. VI, Rec. Q.430.

[9] CCITT Recommendation *Interruption control* , Vol. VI, Rec. Q.416, §§ 2.4.3.2 and 2.4.3.3.

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

[11] CCITT Recommendation *Protection against the effect of faulty transmission on groups of circuits* , Vol. VI, Rec. Q.33.

Recommendation G.794

CHARACTERISTICS OF 24-CHANNEL TRANSMULTIPLEXING EQUIPMENTS

(Malaga-Torremolinos, 1984, amended at Melbourne, 1988)

1 Introduction

The 24-channel transmultiplexer is a transmultiplexing equipment which satisfies Recommendations G.791 and G.792 and provides interconnection between a digital signal at 1544 kbit/s and two analogue basic groups (24-channel TMUX-P).

2 Digital interfaces

2.1 *Coding law*

The coding law used is μ-law specified in Recommendation G.711.

2.2 *Interfaces*

The 1544 kbit/s interfaces satisfy Recommendation G.703, § 2.

2.3 *Frame structure*

The 1544 kbit/s frame structure satisfies Recommendation G.704, § 3.1.1.

2.4 *Multiframe structure*

The multiframe structure carried on the F-bit satisfies Recommendation G.704, § 3.1.1.

3 Analogue interfaces

3.1 *Ports*

The analogue interface consists of two 12-channel groups (band 60-108 kHz) which satisfies Recommendation G.232.

The preferred signal levels at the group distribution frame satisfy Recommendation G.233.

3.2 *Pilots*

The 24-channel transmultiplexer should transmit and receive the group pilot in Recommendation G.241.

3.3 *Pilot detection and regulation*

The transmultiplexer may or may not regulate levels on the basis of the levels of the group pilots. If so, the transmultiplexer must meet the conditions of Recommendation G.241.

4 Correspondence between analogue and digital channels

A fixed correspondence is established between the analogue and digital channels. The following correspondence:

PCM 1: Basic group 1

Channels 1 to 12: 60-108 kHz

PCM 1: Basic group 2

Channels 13 to 24: 60-108 kHz

5 Synchronization of transmultiplexer

The transmultiplexer must produce virtual analogue carrier frequencies with the accuracy specified in Recommendation G.225 (± | 0^{D}lF261^{7}).

For this purpose, it is recommended:

a) either that the transmultiplexer should have an internal clock of sufficient accuracy;

b) or that the transmultiplexer should be synchronizable with an external signal which may be:

1) a frequency produced by a central generator: 4, 12, 124 kHz;

2) or one of the incoming PCM streams which has sufficient accuracy (this may be the case, for example when this PCM stream 1544 kbit/s is produced by a TDM switching equipment).

Note 1 — In the case of a digital filtering transmultiplexer, when synchronization on the incoming PCM stream is not possible, the remote digital terminal should have the sending side synchronized with the receiving side so as to avoid slipping at the transmultiplexer input.

Note 2 — In the case of external synchronization, transmultiplexers often have an internal oscillator locked to the external signal. If, upon loss of the external sync signal, this internal oscillator is allowed to continue to supply the clock for the outgoing digital signal (now in the free-running mode), then this oscillator should have a minimum free-running accuracy of 50×10^{D}lF261^{6}. This is intended to allow the distant end digital terminal to receive an adequate frequency for alarm purposes only, so as not to confuse maintenance and trouble-shooting activities. Also, a local alarm should be given in the event of a fault in the synchronization system or in the absence of the external synchronization signal.

Note 3 — In the case where the transmultiplexer is to be used in a TDMA satellite application, the effect of the satellite Doppler frequency variation must be taken into account. This can be done in two ways:

— either, the TDMA terminal incorporates the Doppler buffer memories of appropriate capacity in the earth station to satellite direction. In this case, the two directions of the TMUX must be synchronized from one of the two 1544 kbit/s PCM streams transmitted by the TDMA receive terminal;

— or, the TDMA terminal does not incorporate Doppler buffers. In this case, the PCM to FDM direction of the TMUX may be synchronized from one of the two 1544 kbit/s streams transmitted by the TDMA receive terminal. In the FDM to PCM direction, the 1544 kbit/s streams transmitted by the TMUX must be made synchronous with the TDMA system transmit clock: this supposes that a synchronization signal (contradirectional with the data) is provided by the TDMA transmit terminal to the TMUX. In the case where the processing in a digital filtering transmultiplexer is made synchronously for the two directions, Doppler buffer memories of appropriate capacity must be incorporated in the PCM interfaces.

6 Signalling

Two different approaches can be envisaged:

6.1 *No signalling translation in TMUX*

This is applicable to applications such as in-band end-to-end signalling, and common channel signalling such as CCITT No. 6 or CCITT No. 7.

6.2 *Translation of analogue signalling (Recommendation Q.21) into 1544 kbit/s PCM line signalling (Recommendation G.733)*

This translation is applicable to the predominant forms of analogue and digital signalling recommended by CCITT for international circuits (excluding signalling system R2) consisting of 12-channel analogue groups *and* 1544 kbit/s PCM digital signals.

7 Fault conditions and consequent actions

The principle governing the handling of alarms is as follows:

The behaviour of the 24-channel transmultiplexer vis-`a-vis a 24-channel PCM multiplex equipment should be the same as that of another 24-channel PCM multiplex equipment. Vis-`a-vis a channel translator, it should behave like another channel translator.

Table 1/G.794 summarizes the fault conditions and consequent actions in accordance with the frame structure, defined in Recommendation G.704.

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H.T. [1T1.794]

TABLE 1/G.794

Fault conditions and consequent action for the 24-channel transmultiplexer

{ Consequent Action Fault Conditions }	{ Prompt maintenance alarm indication (7) }	{ Alarm indication to the remote equipment (3) }	{ Blocking of faulty speech channels }	{ Pilot cut-off to the remote FDM terminal }	
{ Loss of frame alignment and multiframe alignment or Loss of incoming signal (2) }	Yes (8)	Yes	Yes (PCM | > | DM)		
Digital error ratio 10^{D}lF261^{4} or 10^{D}lF261^{3} (10) }	Yes (8) Reception of alarm indication from the remote equipment (2, 3) }	Yes	{ AIS receiving (4)		
Yes	Yes (PCM | | > | DM)				
Pilot level deviation alarm (11) }	Yes	Absence of group pilot (5)	Yes (9)	Yes	
Yes, if regulation is present					
Yes, depending on network applications }	Failure of power supply (2)	Yes	{ System failure (6)	Yes	
{ Yes, depending on network applications }	{ Yes, depending on network applications }	{ Yes, depending on network applications }	{ Yes, depending on network applications }	Synchronization failure	Yes

Note 1 — A *Yes* in the table signifies that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should not be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — The fault conditions ‘‘Loss of incoming signal’’, ‘‘Loss of frame alignment and multiframe alignment’’, ‘‘Reception of alarm indication to the remote equipment’’ and ‘‘Failure of power supply’’ are defined in Recommendation G.733.

Note 3 — For ‘‘Alarm indication to the remote equipment’’, data link bits are used.

Note 4 — The AIS can be used only in the new frame structure to be specified by Study Group XVIII.

Note 5 — The level, at which ‘‘Absence of group pilot’’ is detected, is under study.

Note 6 — The ‘‘System failure’’, which is only for the digital filtering transmultiplexer, corresponds to a fault detected by the transmultiplexer’s supervision system, when it has one.

Note 7 — The consequent action ‘‘Prompt maintenance Alarm indication’’ and ‘‘Alarm indication to the remote equipment’’ are defined in Recommendation G.733.

Tableau 1/G.794 [1T1.794], p. 14

H.T. [2T1.794]

Note 8 — When AIS is detected, the ‘‘Prompt maintenance alarm indication’’ associated with the ‘‘Loss of frame alignment and multiframe alignment’’ with the ‘‘Loss of incoming signal’’ or with the ‘‘Digital error ratio 10^{D}lF261^{4},’’ should be blocked.

Note 9 — The AIS is sent only if the 24 channels of a single PCM stream are in the alarm condition.

Note 10 — Depends on network applications.

Note 11 — ‘‘Pilot level deviation alarm’’ corresponds to a variation on the level of the incoming pilot from its nominal value by more than ± | dB, as stated in CCITT Recommendation G.241, § 1. This applies only to transmultiplexers with automatic internal level regulation.

Pour Montage : System alarm FDM alarm PCM alarm

H.T. [T1.795]
FDM codecs

Administration	Analogue interface	Digital interface	Noise performance
British Telecom	Supergroup (312-552 kHz)	8 | 48 kbit/s	< 140 pW0p
British Telecom 15 SG assembly (312-4025 kHz) }	{ 68 | 36 kbit/s	< 700 pW0p	
China Mastergroup (812-2044 kHz or 60-1300 kHz) }	{ 34 | 68 kbit/s	< 783 pW0p	
NTT	Group (60-108 kHz)	1 | 44 kbit/s	< 340 pW0p

Tableau 1/G.794 [2T1.794], p. 15

Recommendation G.795

CHARACTERISTICS OF CODECS FOR FDM ASSEMBLIES

(Malaga-Torremolinos, 1984, amended at Melbourne, 1988)

The CCITT,

considering

that codecs capable of encoding/decoding FDM assemblies will:

a) be a useful element in the transmission networks of some Administrations during the period of transition from analogue to digital working;

b) have a limited life and application;

c) already be available in a number of realizations,

recommends

that FDM codecs should conform with the following requirements:

1 General

This Recommendation gives details of the analogue interfaces, the overall analogue-to-analogue performance of a coder/decoder pair and certain details of the digital interfaces to which FDM codecs should conform. The CCITT does not recommend any particular relationship between FDM assemblies and the digital hierarchies to be used in any codec realization nor does it recommend any particular frame structure or encoding law. Administrations intending to use codecs in their networks should ensure that compatible designs of codec are used at each end of a link. For international links, the codecs to be used should be by the agreement of the Administrations concerned. An Annex to this Recommendation gives details supplied by some Administrations of a number of FDM codec realizations.

The application of FDM codecs in a network is explained in Supplement No. 28.

2 Analogue interfaces

2.1 *FDM assemblies*

The constitution of the FDM assemblies at the analogue input and output should conform to Recommendation G.211, Figure 1 | fIa) /G.211, for the basic group and Recommendation G.233, Figures 1/G.233 through 5/G.233, as appropriate for the basic supergroup, mastergroup, supermastergroup and 15 supergroup assemblies.

2.2 *Impedances and relative levels*

The impedances and relative levels at the analogue transmission ports should be as indicated in Recommendation G.233, §§ 3 through 6.

2.3 *Return loss*

The return loss against the nominal impedance of all analogue transmission ports should be at least 20 dB in the wanted frequency band. This limit relates to the intrinsic return loss, i.e. that is 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 making links.

2.4 *Accuracy of carrier frequencies*

Designers of FDM codecs may find it expedient to translate the analogue signal frequency before coding and after decoding. The accuracy of any carrier frequencies used should conform to Recommendation G.225. It is possible to lock the carriers to the digital signal so that no overall frequency error is caused by the FDM codecs.

3 Digital interfaces

Digital interfaces should conform to the appropriate sections of Recommendation G.703.

4 Encoding law and frame structure

At present the CCITT does not recommend any particular encoding law or frame structure. In some instances it may not be technically or economically feasible to encode one standardized FDM assembly into one standardized hierarchical bit rate. In these cases it is possible that more than one encoded FDM assembly or an encoded FDM assembly and lower order hierarchical bit streams may be combined to form one standardized hierarchical bit rate conforming to Recommendation G.703. Where one or several encoded FDM assemblies are combined with some lower order hierarchical bit streams, then the multiplexing techniques used must be plesiochronous.

5 Analogue performance

The analogue performance is recommended in terms of the overall performance of a coder/decoder pair.

5.1 *Noise*

A maximum value of 800 pW0p is recommended. In practice, this magnitude of noise is expected to occur only on codecs for the higher order FDM assemblies and that significantly lower values will be achieved with codecs for the smaller FDM assemblies (see the Annex to this Recommendation). The use of FDM codecs on comparatively short transmission paths becomes possible when lower levels of codec noise are achieved. The recommended allowance of noise is intended to take account of all sources of noise, i.e. noise due to:

a) analogue processing before the coder and following the decoder,

b) quantization,

c) errors and jitter on the received digital signal as indicated in the G.900 series of Recommendations.

Noise should be measured in accordance with Recommendation G.230 under the loading conditions given in Recommendation G.222, § 4, for the particular FDM assembly used (see Note).

Note — The contribution to this noise made by errors on the digital transmission path is likely to be small. The effect of errors is to give rise to impulsive type interference and its expression in pW0p depends upon the statistics of the error distribution. However, for design purposes, it should be assumed that errors occurring on the digital line system have a Poisson distribution with a long-term mean error ratio of 10^{-7}.

5.2 *Performance under conditions of light loading*

Under conditions of light loading, the quantizing distortion caused by a discrete tone (e.g. a test tone or signalling frequency) may give rise to a structured noise spectrum containing components considerably in excess of the average quantizing distortion level per channel. However, in practice, the presence of a small number of system reference pilots and carrier leaks is sufficient to maintain an adequately uniform noise spectral distribution.

5.3 *Overload point*

Should be as given in Recommendation G.233, § 6 (see Note).

Note — A higher loading is appropriate if digital speech interpolation techniques or 3 kHz spaced channels (Recommendation G.235) are used.

5.4 *Frequency response*

The amplitude/frequency response, the ratio between wanted and unwanted components and the group delay distortion recommended is that given in Recommendation G.242 for through connections of the relevant FDM assemblies. This performance will be adequate to allow direct connection of the FDM codec analogue ports to the low frequency side of following translating equipment. However, if the analogue ports of the FDM codec are to be directly connected to the high frequency side of translating equipment, then the performance required of the FDM codec may appropriately be that performance normally required by the Administration of its translating equipment.

5.5 *Go-return crosstalk*

The go-return crosstalk ratio should not be worse than 80 dB.

This level of crosstalk may be difficult to measure because of the digital processing in the transmission path. It may be necessary to add to the disturbed path a low level activating signal (a sine wave or band limited white noise) to avoid gain enhancement effects.

5.6 *Unwanted modulation by harmonics of the power supply and other low frequencies*

The combined effect of a coder/decoder pair should correspond to a minimum side component attenuation of 57 dB (Recommendation G.229).

5.7 *Phase jitter*

The phase jitter on a signal caused by a coder/decoder pair should not exceed 1° peak-to-peak when measured in the frequency band given in Recommendation G.229, § 2.

Note — The value quoted above is indicated as guidance for design purposes. In practical applications, the codec should tolerate the jitter of the digital interfaces as specified in Recommendations G.823 and G.824.

6 Fault conditions and consequent actions

The decoder should detect:

a) loss of frame alignment;

b) loss of digital input signal;

c) the presence of Alarm Indication Signal (AIS) on the digital input port.

For all these conditions, the analogue output signal should be suppressed.

Note — Other conditions and consequent actions are under study.

ANNEX A
(to Recommendation G.795)

H.T. [T1.795]
FDM codecs

Administration	Analogue interface	Digital interface	Noise performance
British Telecom	Supergroup (312-552 kHz)	8 | 48 kbit/s	< 140 pW0p
British Telecom 15 SG assembly (312-4025 kHz)	{ 68 | 36 kbit/s }	< 700 pW0p	
China Mastergroup (812-2044 kHz or 60-1300 kHz)	{ 34 | 68 kbit/s }	< 783 pW0p	
NTT	Group (60-108 kHz)	1 | 44 kbit/s	< 340 pW0p

Table [T1.795], p.

Supplement No. 28

APPLICATION OF TRANSMULTIPLEXERS, FDM CODECS, DATA-IN-VOICE (DIV) \| SYSTEMS AND DATA-OVER-VOICE (DOV) SYSTEMS

DURING THE TRANSITION FROM AN ANALOGUE TO A DIGITAL NETWORK

(Referred to in Recommendations G.791 to G.795; this supplement

is to be found on page 397 of Fascicle III.3 of

the *Red Book* , Geneva, 1985.)

Supplement No. 31

STATUS OF WORK OF PRESENTLY CONSIDERED DIGITAL CIRCUIT

MULTIPLICATION EQUIPMENT (DCME) DOCUMENTS

(Melbourne, 1988)

(referred to in Recommendation G.763)

The intent is to achieve a single comprehensive DCME Recommendation based on the current work of various Administrations, recognized private operating agencies and recognized standards bodies.

Consideration is being given to make the CCITT Recommendation on DCME applicable to all circumstances where DCME is required (i.e. cable and satellite, various signalling protocols, etc.). It will be of such detail that equipment conforming to it, but obtained from different design sources, would work together satisfactorily within a single system.

Documents important to the study of a detailed DCME Recommendation (planned and available) include:

INTELSAT — A detailed specification — *INTELSAT earth station standards (IESS)* (Document IEES-501 Rev.1) *digital circuit multiplication equipment specification, 32 kbit/s ADPCM with DSI* , (15 March 1988) has been approved and issued by the INTELSAT Board of Governors.

France — Contribution to Study Group XV, April 1988, *Description of a bearer frame format and associated assignment channel used in the CELTIC-3G DCMS, and performance evaluation* (which incorporates a 2 bit overload strategy on speech signals).

EUTELSAT — Detailed EUTELSAT specification (Document BS14-49), *DCME specification, 32 kbit/s ADPCM and DSI* , May 1988, approved by the EUTELSAT Board of Signatories (Note 1).

Committee T1 — *Digital circuit multiplication equipment interworking standard* , under study with draft standard scheduled for submission for voting at the end of 1988 (Note 2).

Note 1 — This specification is based in a large part on the INTELSAT specification IESS-501 Rev.1 with modifications and additions appropriate to the European: countries (particularly R2D signalling system accomodation).

Note 2 — The current draft is based in large part on the INTELSAT specification IESS-501, 16 September 1987, with modifications appropriate to the US national situation.

Supplement No. 32

TRANSFER OF ALARM INFORMATION ON 60-CHANNEL | TRANSMULTIPLEXING EQUIPMENT

(Melbourne, 1988)

(referred to in Recommendation G.793)

1 Introduction

In the transition period from analogue to digital networks, interconnection between analogue and digital systems will be necessary. In some cases, transmultiplexing equipment can provide the necessary interconnection as described in Supplement No. 28 of Volume III of the Red Book [1].

Due to the different number of channels contained in the various FDM assemblies and TDM arrangements in both analogue and digital hierarchies, the transmission of alarm information may lead to some difficulties (e.g. blocking of non-faulty channels, etc.) if no special means are foreseen.

Methods for alarm transfer based on international standardized signalling systems are already described in Recommendations G.793. The basic principles are summarized in § 3 below. Other solutions can be implemented in national networks or in international networks by bilateral agreement. Paragraph 4 describes a number of possible methods used by various Administrations.

2 Principles of transmultiplexing

2.1 *Correspondence between FDM and TDM hierarchies* (see Figure 1)

According to Recommendation G.793, the relationship is as shown in Table 1.

H.T. [T1.32]
TABLE 1

Group	Analogue channels	PCM	PCM channels
1	1 to 12	1	1 to 12
2	1 to 12	1	13 to 24
3	1 to 6	1	25 to 30
3	7 to 12	2	1 to 6
4	1 to 12	2	7 to 18
5	1 to 12	2	19 to 30

Note — In national networks or by agreement between Administrations, other schemes of correspondence between analogue and digital channels may be used.

Tableau 1 [T1.32], p. 17

2.2 *Detection of fault conditions in transmultiplexers*

According to the specification in Rec. G.793, the following fault conditions are detected in transmultiplexers:

a) *digital side*

— loss of incoming signal, error ratio greater than 10^{D}lF261^{3}, loss of frame alignment;

— loss of multiframe alignment (when used);

— detection of a remote alarm.

b) *analogue side*

— loss of group pilot;

— loss of supergroup pilot;

— pilot level deviation alarm.

c) system alarm

— failure of power supply;

— system failure (if in-service monitoring is implemented);

— synchronization failure.

2.3 *Transmission of alarm information* (see Figure 1)

a) *FDM towards TDM*

If one of the group pilots fails, then for the relevant group an individual alarm should be transmitted from the analogue side to the relevant digital output port of the transmultiplexer. In the 60 channel-TMUX, this creates a specific problem in the case of *group 3* , which is split between the two digital streams.

b) *TDM towards FDM*

In the 60 channel-TMUX, if only one of the two digital incoming composite streams fails, no group pilot should be sent to the analogue output port of the transmultiplexer for groups 1 and 2 (or 4 and 5 respectively) and for group 3 where 6 non-faulty channels might then be out of service (see § 3).

In both cases, some kind of per channel alarm information is required to solve the difficulties.

3 Alarm transfer based on international standardized signalling systems

When the 2-bit version of Signalling System R2 is used on the digital side of a TMUX, then a conversion between the digital and the analogue versions of R2 is performed in the TMUX, according to Recommendation Q.430. This conversion allows some alarm transfer on a per-channel basis of the signalling information itself (on the digital side, bits *a* and *b* of time slot 16 are used completely for signalling). Table 2/G.793 refers to this method.

For in-band signalling and common channel signalling, Table 3/G.793 gives the fault conditions and consequent actions. However, the problem of alarm transfer on a per channel basis has not yet been solved, and is currently being studied by Study Group XI for supervision of TDMA/DSI satellite systems.

One possibility is to use bits *a* or *b* of time slot 16 to transmit some alarm indication on a per-channel basis from FDM to PCM, as in the case of the analogue version of S.S.R2 (see § 4.1 below). However, in the opposite direction, when only one PCM stream fails, it is in principle either possible to block 6 non-faulty channels, or not to block 6 faulty channels. Since in the latter case subscribers may be charged even though they are not connected by a speech path, it is preferable to adopt the first alternative.

Alternative methods of alarm transfer are in use in national applications and these are described in § 4 below.

Figure 1, p. 18

4 Methods of alarm transfer used in national applications

4.1 *Analogue version of Signalling System R2*

4.1.1 In national networks, the following arrangements conforming to [2] may be used when the circuits connected to the transmultiplexer are operated with the Signalling System R2.

The 60-channel transmultiplexer establishes a correspondence between the signalling data carried by time slots 16 of the PCM frames and the out-of-band signalling frequencies at 3825 Hz. The specifications concerning these signalling frequencies are contained in Recommendations Q.414 and Q.415.

The signalling bit *a* associated with a channel is used to transmit the presence or absence of the signalling frequency in that channel. The signalling bit *b* associated with a channel is used to transmit alarm information to the channel in the FDM to PCM direction, when the loss of the group pilot carrying the channel is detected.

In this organization, the principles governing the handling of alarms is as follows:

— priority is given to the correct functioning of the interruption control system (Recommendation Q.416);

— the behaviour of a transmultiplexer vis-`a-vis a 30 channel PCM multiplex should be the same as that of another 30-channel PCM multiplex. However, the transmultiplexer performs certain functions peculiar to digital multiplexing equipments, such as the emission of the AIS. Vis-`a-vis a group modulator, it should behave like another group modulator.

Table 2 summarizes fault conditions and consequent actions.

4.1.2 The same solution may also be used for another national out-of-band signalling systems.

4.1.3 In some cases, it may be desirable for the transmultiplexer to provide locally the information control information relating to the various groups.

4.2 *Other out-of-band signalling systems*

The same methods as for the analogue version of Signalling System R2 can be used. Table 2 also applies.

4.3 *Multiframe in combination with inband and common channel signalling system* [3]

4.3.1 *Inband signalling (Signalling Systems No. 4 and 5)*

In the case of inband signalling, normally no multiframe alignment exists. Therefore time slot 16 may be used for transmission of additional signals, e.g. data signals. In this case, there is no possibility for transmission of pilot-alarms.

If time slot 16 is not used for transmission of additional signals, bit *a* or bit *b* of this time slot can be used for transmission of pilot-alarms in the FDM PCM direction. In this case, multiframe alignment is necessary.

In the PCM FDM direction Note 5 of Table 3.

4.3.2 *Common channel signalling*

The following refers only to Signalling System No. 7. This system is optimized for operation in digital telecommunication networks over 64 kbit/s digital channels (see Rec. Q.701). Therefore, digital data links should be preferred. But analogue transmission rates over 4 kHz or 3 kHz channels and modems, e.g. with 2400 bit/s is also possible (Recs. Q.701, Q.702) if no digital channel is available.

Low speed signalling data links can be transmitted over a transmultiplexer. Fault conditions and consequent actions are the same as for inband signalling. (See Table 3)

H.T. [1T2.32]

TABLE 2
{
Fault conditions and consequent actions, applicable for national networks where Signalling System R2, 1-bit analogue version, is used
(see Note 1)
}

Fault conditions	Consequent actions				
	{				
Loss of signal Error ratio > 10^{D}lF261^{3} Loss of frame alignment (see Note 2) }	{ Yes (see Note 4)	Yes	Yes PCM | > | DM	Yes PCM | > | DM	Yes (
Loss of multitrame alignment (see Note 2) }	{ Yes (see Note 4)	Yes	Yes PCM | > | DM	Yes (see Note 5)	
Absence of received group pilot (see Note 6) }	{ Yes	Yes FDM | > | CM	Yes FDM | > | CM	Yes (see Note 7)	Yes (see
Absence of the received supergroup pilot (see Note 8) }	{ Yes				
Pilot level deviation alarm (Note 9) }	{ Yes				
	Failure of poser supply	Yes	Yes, if possible	Yes, if possible	
System failure (see Note 10) }	{ Yes	Yes, 5 groups	Yes (see Note 7)	Yes (see Notes 3 and 7)	
Synchronization failure (see Note 11) }	{ Yes				

Pour Montage : System alarms FDM alarms PCM alarms

Tableau 2 [1T2.32] (a l'italienne), p. 19

H.T. [2T2.32]

Note 1 — A *Yes* | n the table signifies, that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the condition, a *Yes* is defined in relation to this action.

Note 2 — The fault conditions ''Loss of signal at 2 Mbit/s'', ''Error ratio > 10^{D}lF261^{3},'', ''Loss of frame alignment'', ''Loss of multiframe alignment'' and the consequent action ''Bit 3, time slot 0 to 1'', ''Bit 6, time slot 16, frame 0 to 1'' and ''AIS sent'' are defined in Recommendation G.732.

Note 3 — Bits *b* of time slot 16 are used for channel associated transmission of the alarm of an individual group pilot of the affected 12 channels if the FDM PCM direction, so as to ensure the correct functioning of the interruption control, without having to suppress channels that are not necessarily faulty, for example, in the case of a fault on a single group. In the case of group 3, bits *b* of the concerned 2×6 channels of the two 2048 kbit/s bit streams are affected.

Note 4 — The 60-channel transmultiplexer should be able to detect the Alarm Indication Signal (AIS) on incoming streams at 2048 kbit/s. When AIS is detected, the prompt maintenance indication associated with the loss of frame alignment, with an excessive error rate or with the loss of multiframe alignment should be blocked.

Note 5 — In the PCM FDM direction, the pilots must be cut for the 3 groups associated with a PCM multiplex signal in the event of the detection of a fault on the PCM multiplex signal stream. When a single PCM multiplex signal is faulty, this involves the blocking of 6 channels which are not faulty.

Note 6 — The definition of absence of group pilot used for the operation of the interruption control system is given in the Recommendation Q.416, §§ 2.4.3.2 and 2.4.3.3. The supergroup pilot can also be used.

Note 7 — The AIS is sent only if the 30 channels of a single PCM stream are in the alarm condition. The sending of AIS then has priority over the setting of bit *b* of time slot 16 to 1.

Note 8 — Detection of ''absence of supergroup pilot'' is not obligatory. If the supergroup pilot is not sent, this alarm function can be performed by supervision of the 5 group pilots.

Note 9 — The concept of pilot level deviation alarm corresponds to a variation on the level of the pilot from its nominal value by more than ± | dB, as stated in Recommendation G.241, § 1. This applies only to transmultiplexers with automatic internal level regulation.

Note 10 — The ''system'' fault condition corresponds to a fault on the transmultiplexer detected by the transmultiplexer's supervision system, when it has one.

Note 11 — The ''synchronization'' fault is that mentionned in § 6 of Recommendation G.793. When the transmultiplexer is synchronized with an external signal or with one of the two incoming PCM streams at 2048 kbit/s, the transmultiplexer should transmit an alarm signal in the event of synchronization loss.

H.T. [1T3.32]

TABLE 3
{
Fault conditions and consequent sections for inband signalling systems and common channel signalling systems with low bit rates
(Note 1)
}

Fault conditions	Consequent actions			
	{			
Loss of signal Error ratio > 10^{-3} Loss of frame alignment (see Note 2) }	{ Yes (see Note 4)	Yes	Yes PCM > FDM	Yes (see Note 5)
Loss of multiframe alignment (see Note 2) (optional) }	{ Yes (see Note 4)	Yes	Yes (see Note 5)	
Absence of the received group pilot (see Note 6) }	{ Yes	Yes FDM > PCM	Yes (see Note 7)	Yes (see Notes 3 and 7)

{
Absence of the received supergroup pilot (see Note 8)
}
	Yes			

{
Pilot level deviation alarm (see Note 9)
}
	Yes			

Failure of power supply	Yes	Yes, if possible	Yes, if possible	
System failure (see Note 10)	Yes	Yes, 5 groups	Yes (see Note 7)	Yes (see Notes 3 and 7)

{
Synchronization failure
(see Note 11)
}
	Yes			

Note 1 — A *Yes* in the table signifies, that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

POUR MONTAGE: System alarms FDM alarms PCM alarms

Remarques du Tableau 2 [2T2.32], p. 20

H.T. [1T3.32]

TABLE 3
{
Fault conditions and consequent sections for inband signalling systems and common channel signalling systems with low bit rates
(Note 1)
}

Fault conditions	Consequent actions			
{ Loss of signal Error ratio > 10^{D}lF261^{3} Loss of frame alignment (see Note 2) }	Yes (see Note 4)	Yes	Yes PCM > FDM	Yes (see Note 5)
{ Loss of multiframe alignment (see Note 2) (optional) }	Yes (see Note 4)	Yes	Yes (see Note 5)	
{ Absence of the received group pilot (see Note 6) }	Yes	Yes FDM > PCM	Yes (see Note 7)	Yes (see Notes 3 and 7)
{ Absence of the received supergroup pilot (see Note 8) }	Yes			
{ Pilot level deviation alarm (see Note 9) }	Yes			
Failure of power supply	Yes	Yes, if possible	Yes, if possible	
System failure (see Note 10)	Yes	Yes, 5 groups	Yes (see Note 7)	Yes (see Notes 3 and 7)
{ Synchronization failure (see Note 11) }	Yes			

Note 1 — A *Yes* | n the table signifies, that an action should be taken as a consequence of the relevant fault conditions. An open space in the table

signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

POUR MONTAGE: System alarms FDM alarms PCM alarms

Tableau 3 [T3.32] (a l'italienne), p. 21

H.T. [2T3.32]

Note 2 — The fault conditions ‘‘Loss of signal at 2 Mbit/s’’, ‘‘Error ratio > 10^{D}lF261^{3},’’, ‘‘Loss of frame alignment’’, ‘‘Loss of multiframe alignment’’ and the consequent action ‘‘Bit 3, time slot 0 to 1’’, ‘‘Bit 6, time slot 16, frame 0 to 1’’ and ‘‘AIS sent’’ are defined in Recommendation G.732.

Note 3 — Bits *b* of time slot 16 are used for channel associated transmission of the alarm of an individual group pilot of the affected 12 channels if the FDM PCM direction, so as to ensure the correct functioning of the interruption control, without having to suppress channels that are not necessarily faulty, for example, in the case of a fault on a single group. In the case of group 3, bits *b* of the concerned 2×6 channels of the two 2048 kbit/s bit streams are affected.

Note 4 — The 60-channel transmultiplexer should be able to detect the Alarm Indication Signal (AIS) on incoming streams at 2048 kbit/s. When AIS is detected, the prompt maintenance indication associated with the loss of frame alignment, with an excessive error rate or with the loss of multiframe alignment should be blocked.

Note 5 — In the PCM FDM direction, the pilots must be cut for the 3 groups associated with a PCM multiplex signal in the event of the detection of a fault on the PCM multiplex signal stream. When a single PCM multiplex signal is faulty, this involves the blocking of 6 channels which are not faulty.

Note 6 — The definition of absence of group pilot used for the operation of the interruption control system is given in the Recommendation Q.416, §§ 2.4.3.2 and 2.4.3.3. The supergroup pilot can also be used.

Note 7 — The AIS is sent only if the 30 channels of a single PCM stream are in the alarm condition. The sending of AIS then has priority over the setting of bit *b* of time slot 16 to 1.

Note 8 — Detection of ‘‘absence of supergroup pilot’’ is not obligatory. If the supergroup pilot is not sent, this alarm function can be performed by supervision of the 5 group pilots.

Note 9 — The concept of pilot level deviation alarm corresponds to a variation on the level of the pilot from its nominal value by more than ± | dB, as stated in Recommendation G.241, § 1. This applies only to transmultiplexers with automatic internal level regulation.

Note 10 — The ‘‘system’’ fault condition corresponds to a fault on the transmultiplexer detected by the transmultiplexer’s supervision system, when it has one.

Note 11 — The ‘‘synchronization’’ fault is that mentionned in § 6 of the Recommendation G.793. When the transmultiplexer is synchronized with an external signal or with one of the two incoming PCM streams at 2048 kbit/s, the transmultiplexer should transmit an alarm signal in the event of synchronization loss.

H.T. [1T4.32]

TABLE 4
{
Fault conditions and consequent actions for common channel signalling using combinations of cut group pilots
(Note 1)
}

{

Loss of signal Error ratio > 10^{D}lF261^{3} Loss of frame alignment }	{ PCM 1 (Note 2)	Yes	Yes	Yes	Yes	PCM | > | DM	Yes (Note
Loss of signal Error ratio > 10^{D}lF261^{3} Loss of frame alignment }	{ PCM 2 (Note 2)	Yes	Yes	Yes	Yes	PCM | > | DM	Yes (Note
Loss of 64 kbit/s PCM 1 input (Note 4) }	{ Yes	Yes					
Loss of 64 kbit/s PCM 2 input (Note 4) }	{ Yes	Yes					
	Bit 3, time slot 0: PCM 1	Yes	Yes	Optional			
Bit 3, time slot 0: PCM 2 }	{ Yes	Yes	Optional				
Loss of Group 1 and Group 2 but not Group 3 }	{ Yes	Optional					
Any other combination of Group 1, 2 and 3 losses }	{ Yes	Yes	Yes	Yes			
Loss of Group 4 and Group 5 but not Group 3 }	{ Yes	Optional					
Any other combination of Group 3, 4 and 5 losses }	{ Yes	Yes	Yes	Yes			
Loss of supergroup pilot (Note 5) }	{ Yes						
Pilot level deviation alarm (Note 6)	{						

}	Yes					

Remarques du Tableau 3 [2T3.32] + Remarques, p. 22

4.4 *Fault conditions and consequent actions for common channel signalling using combinations of cut group pilots*

The alarm transfer procedure detailed in Table 4 is used in a TMUX-TMUX and a TMUX-GTE/CTE/PCM MUX link used by BT (United Kingdom). Figure 2 shows how these two types of link are implemented. The method uses combinations of cut group pilots to transfer standard digital alarms across the analogue portion of the link. One pilot is cut to signal a forward alarm and two pilots are cut to signal a backward alarm. The FDM path is thus effectively transparent to digital alarms, giving consistency with systems which are entirely digital. Key features of this method are that it does not require that alarms be transferred on a per-channel basis and it ensures that all faulty channels are blocked. It therefore avoids the problems mentioned in § 3 above.

No modifications are required to the implementation of the common channel signalling system. The 64 kbit/s common channel signalling channel is extracted from PCM 1 or PCM 2 and sent over one group via a modem.

Blanc

Figure 2, p. 23

H.T. [1T4.32]

TABLE 4
{
Fault conditions and consequent actions for common channel signalling using combinations of cut group pilots
(Note 1)
}

{

Loss of signal Error ratio > 10^{-3} Loss of frame alignment }	PCM 1 (Note 2)	Yes	Yes	Yes	Yes	PCM | > | DM	Yes (Note
Loss of signal Error ratio > 10^{-3} Loss of frame alignment }	PCM 2 (Note 2)	Yes	Yes	Yes	Yes	PCM | > | DM	Yes (Note
Loss of 64 kbit/s PCM 1 input (Note 4) }	Yes	Yes					
Loss of 64 kbit/s PCM 2 input (Note 4) }	Yes	Yes					
	Bit 3, time slot 0: PCM 1	Yes	Yes	Optional			
Bit 3, time slot 0: PCM 2 }	Yes	Yes	Optional				
Loss of Group 1 and Group 2 but not Group 3 }	Yes	Optional					
Any other combination of Group 1, 2 and 3 losses }	Yes	Yes	Yes	Yes			
Loss of Group 4 and Group 5 but not Group 3 }	Yes	Optional					
Any other combination of Group 3, 4 and 5 losses }	Yes	Yes	Yes	Yes			
Loss of supergroup pilot (Note 5) }	Yes						
Pilot level deviation alarm (Note 6)							

}	Yes						

Tableau 4 [1T4.32] (à l’italienne), p. 24

H.T. [2T4.32]

TABLE 4 *(cont.)*

{								
	Failure of power supply	If possible	If possible	If possible	If possible	If possible	If possible	Y
	System failure (Note 7)	Yes	Yes	Yes	Yes	Yes	Yes	Y
Synchronization failure (Note 8) }	{ Yes	Yes	Yes	Yes	Yes	Yes	Yes	Y

Note 1 — A *Yes* | n the table signifies, that an action should be taken as a consequence of the relevant fault conditions. An open space in the table signifies that the relevant action should *not* be taken as a consequence of the relevant fault condition, if this condition is the only one present. If more than one fault condition is simultaneously present, the relevant action should be taken if, for at least one of the conditions, a *Yes* is defined in relation to this action.

Note 2 — The fault conditions ‘‘Loss of signal’’, ‘‘Error ratio > 10^{D}lF261^{3},,, ‘‘Loss of frame alignment’’, ‘‘Loss of multiframe alignment’’ and the consequent action ‘‘Bit 3, time slot 0 to 1’’, and ‘‘AIS sent’’ are defined in Recommendation G.732.

Note 3 — The TMUX should be able to detect the alarm indication signal (AIS) on incoming streams at 2048 kbit/s. When AIS is detected, the prompt maintenance indication associated with the loss of frame alignment and/or an excessive error ratio should be blocked.

Note 4 — For transmultiplexers not required to handle common channel signalling, in either or both PCM streams, it shall be possible to program the TMUX to suppress the alarms associated with these fault conditions.

Note 5 — Detection of absence of supergroup pilot is not obligatory. If the supergroup pilot is not sent, this alarm function can be performed by supervision of the 5 group pilots.

Note 6 — The concept of pilot level deviation alarm corresponds to a variation on the level of the pilot from its nominal value by more than ± | dB as stated in Recommandation G.241, § 1. This applies only to transmultiplexers with automatic internal level regulation.

Note 7 — The ‘‘system’’ fault condition corresponds to a fault on the transmultiplexer detected by the transmultiplexer’s supervision system, when it has one.

Note 8 — The ‘‘synchronisation’’ fault is that mentioned in § 6 of Recommendation G.793. When the transmultiplexer is synchronized with an external signal or with one of the two incoming PCM streams at 2048 kbit/s, the transmultiplexer should transmit an alarm signal in the event of synchronisation loss.

Pour Montage : FDM alarms PCM alarms System alarms

Remarques du Tableau 4 [2T4.32], p. 25

References

[1] Supplement No. 28 *Applications of transmultiplexers, FDM Codecs, data-in-voice (DIV) systems and data-over-voice (DOV) systems during the transition from an analogue to a digital network* , Red Book, Vol. III.3, Geneva, 1985.

[2] Supplement No. 3 *Use of the analogue line signalling version on 2048 kbit/s PCM transmission systems* , Blue Book, Vol. VI, Fascicle VI.4.

[3] Contribution COM XV-29 (Federal Republic of Germany), Study Period 1985-88.

[4] Contribution COM XV-58 (United Kingdom), Study Period 1985-88.