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GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS

TERMINAL EQUIPMENTS

CHARACTERISTICS OF 60-CHANNEL TRANSMULTIPLEXING EQUIPMENTS

ITU-T Recommendation G.793

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation G.793 was published in Fascicle III.4 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation G.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 411 920 Hz and a level of -20 dBm0,

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

Group 1: 335 920 Hz
Group 2: 383 920 Hz
Group 3: 431 920 Hz
Group 4: 479 920 Hz
Group 5: 527 920 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.

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.

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, $\pm 50 \cdot 10^{-6}$).

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] ($\pm 10^{-7}$).

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^{-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-à-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-à-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 [l1].

TABLE 2/G.793

Fault conditions and consequent actions, applicable if Signalling System R2 is used (see Note 1)

Fault conditions		Consequent actions						
		Prompt maintenance alarm indication generated	Alarm indication transmitted to the remote end		Blocking of faulty speech channels	Information to be taken into account in conversion	Transmission of alarms	
			Bit 3 0 to 1 (see Note 2)	Bit 6 time slot 16, frame 0 to 1 (see Note 2)			Pilot cut-out	AIS sent (see Note 2)
PCM alarms	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	(see Note 4)	
	Loss of multiframe alignment (see Note 2)	Yes (see Note 3)		Yes		a = b = 1	(see Note 4)	
	Reception of bit 3, time slot 0 or bit 6, time slot 16, frame 0 (see Note 2)					a = b = 1		
FDM alarms	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				Absence of pilot		
	Pilot level deviation alarm (Note 8)	Yes						
System alarms	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.

Note 2 - The fault conditions "Loss of signal at 2 Mbit/s", "Error ratio > 10^{-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 ± 4 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 transmultiplexers supervision system, when it has one.

Note 10 - The "synchronization" fault is that mentioned 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.

TABLE 3/G.793

Fault conditions and consequent actions, applicable for in-band signalling and common channel signalling
(Note 1)

Fault conditions		Consequent actions				
		Prompt maintenance alarm indication generated	Alarm indication transmitted to the remote end: Bit 3, time slot 0 to 1 (see Note 2)	Blocking of faulty speech channels	Transmission of alarms: Pilot cut-out	Transmission of alarms: AIS sent (see Note 2)
PCM alarms	Loss of signal Error ratio > 10^{-3} Loss of frame alignment (see Note 2)	Yes (see Note 3)	Yes	Yes PCM→ FDM	Yes (see Note 4)	
IDM alarms	Absence of the received supergroup pilot (see Note 5)	Yes		Yes FDM→ PCM		Yes (see Note 6)
	Absence of the received group pilot (see Note 7)	Yes				
	Pilot level deviation alarm (see Note 8)	Yes				
System alarms	Failure of power supply	Yes			Yes, if possible	Yes, if possible
	System failure (see Note 9)	Yes			Yes, 5 groups	Yes (see Note 7)
	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.

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.

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 ± 4 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 mentioned 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.

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.