



INTERNATIONAL TELECOMMUNICATION UNION

**ITU-T**

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

**G.752**

**GENERAL ASPECTS OF DIGITAL TRANSMISSION  
SYSTEMS**

**TERMINAL EQUIPMENTS**

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**CHARACTERISTICS OF DIGITAL MULTIPLEX  
EQUIPMENTS BASED ON A SECOND ORDER  
BIT RATE OF 6312 kbit/s AND USING  
POSITIVE JUSTIFICATION**

**ITU-T Recommendation G.752**

(Extract from the *Blue Book*)

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## NOTES

1 ITU-T Recommendation G.752 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.752

### CHARACTERISTICS OF DIGITAL MULTIPLEX EQUIPMENTS BASED ON A SECOND ORDER BIT RATE OF 6312 kbit/s AND USING POSITIVE JUSTIFICATION

(Geneva, 1976; amended at Geneva, 1980)

The CCITT,

*considering*

- (a) that various third- and higher-order multiplex equipments exist due to the differing characteristics of networks and signal sources in those networks;
- (b) that, although studies will continue with the aim of reducing the differences between various systems, the existing situation cannot be changed in the near future;

*recommends the following*

(1) when countries using 1544 kbit/s primary multiplex equipments, such as the PCM multiplex equipment according to Recommendation G.733 and second-order multiplex using 6312 kbit/s according to Recommendations G.743 and G.746, are planning digital paths requiring interconnection at higher bit rates they should, when practical, utilize third-order bit rates of either 32 064 kbit/s or 44 736 kbit/s. When countries using 32 064 kbit/s third-order multiplex equipments are planning digital paths requiring interconnection at higher bit rates, they should, when practical, utilize the fourth-order bit rate of 97 728 kbit/s.

For Figure 1/G.752 refer to Figure 1/G.702 for the basic multiplex arrangements recommended for Administrations using 1544 kbit/s primary multiplex equipment. The bit rates of terrestrial systems should accommodate multiples of 1544 kbit/s. Whenever practical, the bit rate should also accommodate a multiple of 6312 kbit/s, either 32 064 or 44 736 kbit/s, and 97 728 kbit/s;

- (2) the characteristics of the third-order multiplex equipments using positive justification is given in § 1, below;
- (3) the characteristics of the fourth-order multiplex equipments using positive justification is given in § 2 below.

## **1 Third-order digital multiplex equipment based on second-order bit rate of 6312 kbit/s and using positive justification**

### *1.1 General*

The third-order digital multiplex equipment using positive justification described below, is intended for use on digital paths and between countries using 1544 kbit/s and 6312 kbit/s primary and secondary multiplex equipments.

A bit rate of either 32 064 kbit/s or 44 736 kbit/s is recommended to allow for the efficient and economical coding of wideband signals in the networks of Administrations using primary systems according to Recommendations G.733 and G.743. For instance for a 300 voice-circuit mastergroup (Recommendation G.233 [1]) 32 064 kbit/s is appropriate, while for a 600 voice-circuit mastergroup 44 736 kbit/s coding is appropriate.

### *1.2 Third-order digital multiplex equipment operating at 32 064 kbit/s*

#### *1.2.1 Bit rate*

The nominal bit rate should be 32 064 kbit/s. The tolerance on that rate should be  $\pm 10$  parts per million (ppm).

1.2.2 *Frame structure*

Table 1/G.752 gives:

- the tributary bit rate and the number of tributaries;
- the number of bits per frame;
- the bit numbering scheme;
- the bit assignment;
- the frame alignment signal.

TABLE 1/G.752  
**32 064 kbit/s multiplexing frame structure**

Tributary bit rate (kbit/s)	6312
Number of tributaries	5
Frame structure	Bit number
Bits for frame alignment signal (see Note 1) Bits from tributaries	<i>Set I</i> 1 to 5 6 to 320
$C_{j1}$ ( $j = 1$ to 5) for justification control signal (see Note 2) Bits from tributaries	<i>Set II</i> 1 to 5 6 to 320
$C_{j2}$ ( $j = 1$ to 5) for justification control signal (see Note 2) Bits from tributaries	<i>Set III</i> 1 to 5 6 to 320
Bits for frame alignment (see Note 2) Bits from tributaries	<i>Set IV</i> 1 to 5 6 to 320
$C_{j3}$ ( $j = 1$ to 5) for justification control signal (see Note 2) Bits from tributaries	<i>Set V</i> 1 to 5 6 to 320
Auxiliary bits $H_n$ ( $n = 1, 2, 3, 4, 5$ ) (see Note 4) Bits from tributaries	<i>Set VI</i> 1 to 5 6 to 320
Frame length Bits per tributary (including justification) Maximum justification rate per tributary Nominal justification ratio	1 920 bits 378 bits 16 700 bits 0.036

*Note 1* - The frame alignment signal is a 11010 pattern.

*Note 2* -  $C_{jn}$  indicates the  $n$ th justification control bit of the  $j$ th tributary ( $j = 1$  to 5).

*Note 3* - The frame alignment signal is a 00101 pattern.

*Note 4* -  $H_5$  is used for transmitting failure information from the receive end to the transmit end.

*Note 5* - The bit available for the justification of each tributary is the first slot of the tributary in set VI.

1.2.3 *Loss and recovery of frame alignment and consequent action*

The frame alignment recovery time should not exceed 8 ms. The signal to be applied to the tributaries during the out-of-frame alignment time should be studied.

1.2.4 *Multiplexing method*

Cyclic bit interleaving in the tributary numbering order and positive justification is recommended.

The justification control signal should be distributed and the  $C_{jn}$ -bits should be used ( $n = 1, 2, 3$ , see Table 1/G.752).

Positive justification should be indicated by the signal 111, no justification by the signal 000. Majority decision is recommended.

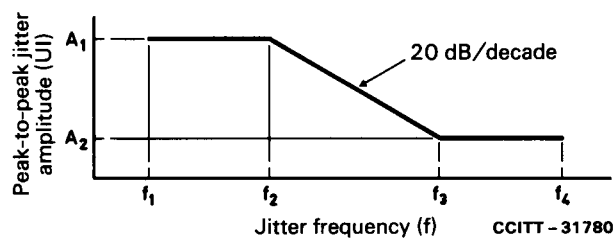
Table 1/G.752 gives the maximum justification rate per tributary and the nominal justification ratio.

1.2.5 *Jitter*

1.2.5.1 *Specifications at the input ports*

The digital signal presented at the input ports shall be as defined in Recommendation G.703 modified by the transmission characteristic of the interconnecting cable. The input ports shall be able to tolerate a digital signal with these electrical characteristics but modified by sinusoidal jitter up to the limits specified by the amplitude frequency relationship in Figure 2/G.752. The equivalent binary content of the signal, with jitter modulation, applied to the inputs shall be a pseudo-random bit sequence of length  $2^{15} - 1$ .

*Note* - The signal with jitter modulation applied to the demultiplexer input shall contain the bits necessary for framing and justification in addition to information bits.



Input	$A_1$ (UI)	$A_2$ (UI)	$f_1$ (Hz)	$f_2$ (kHz)	$f_3$ (kHz)	$f_4$ (kHz)
6312 kbit/s	1	0.05	60	1.6	32	160
32 064 kbit/s (provisional)	5	0.05	60	1.6	160	800

UI Unit interval

FIGURE 2/G.752

**Lower limit of maximum tolerable input jitter**

### 1.2.5.2 *Multiplex signal output jitter*

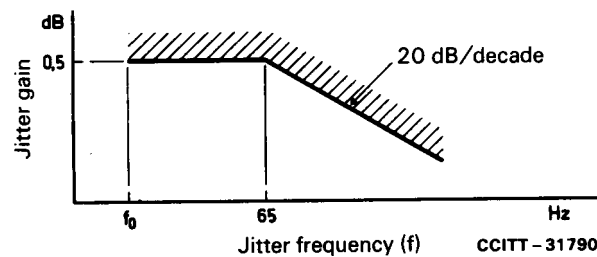
The jitter at the 32 064 kbit/s output of the multiplexer should not exceed 0.01 UI rms.

### 1.2.5.3 *Demultiplexer output jitter with no multiplexer or demultiplexer input jitter*

The peak-to-peak jitter at a tributary output of the demultiplexer with no jitter at the inputs should not exceed 0.2 UI.

### 1.2.5.4 *Demultiplexer jitter transfer characteristic*

A 6312 kbit/s signal, modulated by sinusoidal jitter, should be subject to a demultiplexer jitter transfer characteristic within the gain/frequency limits given in Figure 3/G.752.



*Note* - The frequency  $f_0$  should be as low as possible taking into account the limitations of measuring equipment.

FIGURE 3/G.752

### **Demultiplexer transfer characteristic**

### 1.2.6 *Digital interface*

The digital interfaces at 6312 kbit/s and 32 064 kbit/s should be in accordance with Recommendation G.703.

### 1.2.7 *Timing signal*

If it is economically feasible, it may be desirable to be able to derive the multiplexer timing signal from an external source as well as from an internal source.

### 1.2.8 *Service digits*

The service digits are reserved for national use.

## 1.3 *Third-order digital multiplex operating at 44 736 kbit/s*

### 1.3.1 *Bit rate*

The nominal bit rate should be 44 736 kbit/s. The tolerance on that rate should be  $\pm 20$  parts per million (ppm).

### 1.3.2 *Frame structure* (see Table 2/G.752).

### 1.3.3 *Loss and recovery of frame and multiframe alignment and consequent action*

The frame alignment recovery time should not exceed 2.5 ms. The signal to be applied to the tributaries during the out-of-frame alignment time should be studied. Once frame alignment is established, multiframe alignment should be recovered in less than 250  $\mu$ s.

### 1.3.4 *Multiplexing method*

Cyclic bit interleaving in the tributary numbering order and positive justification is recommended.

The justification control signal should be distributed and the  $C_{jn}$ -bits should be used ( $n = 1, 2, 3$ , see Table 2/G.752).

Positive justification should be indicated by the signal 111, no justification by the signal 000. Majority decision is recommended.

Table 2/G.752 gives the maximum justification rate per tributary and the nominal justification ratio.

TABLE 2/G.752

**44 736-kbit/s multiplexing frame structure**

Tributary bit rate (kbit/s)	6312
Number of tributaries	7
Frame structure (see Note 1)	Bit number
Bit for multiframe alignment signal ( $M_j$ ) (see Note 1)	<i>Set I</i> 1
Bits from tributaries	2 to 85
1st bit for frame alignment signal ( $F_{11}$ ) (see Note 2)	<i>Set II</i> 1
Bits from tributaries	2 to 85
1st bit for justification control signal ( $C_{j1}$ )	<i>Set III</i> 1
Bits from tributaries	2 to 85
2nd bit for frame alignment signal ( $F_0$ )	<i>Set IV</i> 1
Bits from tributaries	2 to 85
2nd bit for justification control signal ( $C_{j2}$ )	<i>Set V</i> 1
Bits from tributaries	2 to 85
3rd bit for frame alignment signal ( $F_0$ )	<i>Set VI</i> 1
Bits from tributaries	2 to 85
3rd bit for justification control signal ( $C_{j3}$ )	<i>Set VII</i> 1
Bits from tributaries	2 to 85
4th bit frame alignment signal ( $F_{12}$ )	<i>Set VIII</i> 1
Bits from tributaries (see Note 3)	2 to 85
Frame length	680 bits
Multiframe length	4760 bits
Bits per tributary per multiframe (including justification)	672 bits
Maximum justification rate per tributary	9398 bit/s
Nominal justification ratio	0.390

*Note 1* - This frame is repeated 7 times to form a multiframe with frames designated  $j = 1, 2, 3, 4, 5, 6, 7$ . The multiframe alignment signal is an XXPP010 pattern where X is a bit assigned to service function, and P is the parity bit for the preceding multiframe (i.e. from  $M_1$  to  $M_7$ ).  $P = 1$  if the number of marks in all tributary bits in the preceding multiframe is odd,  $P = 0$  if the number of marks in all tributary bits in the preceding multiframe is even. Note that the two X bits are identical in any multiframe, as are the two P bits.

Note 2 - The frame alignment signal is  $F_0 = 0$  and  $F_{11} = F_{12} = 1$ .

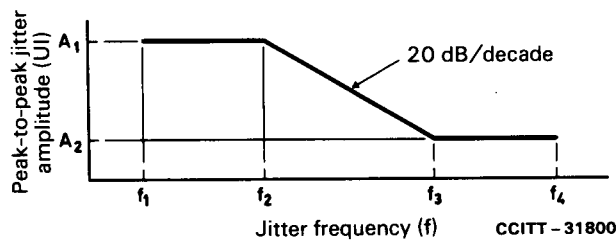
Note 3 - The bit available for the justification of tributary  $j$  is the first slot of tributary  $j$  following  $F_{12}$  in the  $j$ th frame.

### 1.3.5 Jitter

#### 1.3.5.1 Specifications at the input ports

The digital signal presented at the input ports shall be as defined in Recommendation G.703 modified by the transmission characteristic of the interconnecting cable. The input ports shall be able to tolerate a digital signal with these electrical characteristics but modified by sinusoidal jitter up to the limits specified by the amplitude frequency relationship in Figure 4/G.752. The equivalent binary content of the signal, with jitter modulation, applied to the inputs shall be a pseudo-random bit sequence of length  $2^{15} - 1$ .

Note - The signal with jitter modulation applied to the demultiplexer input shall contain the bits necessary for framing and justification in addition to information bits.



Input	$A_1$ (UI)	$A_2$ (UI)	$f_1$ (Hz)	$f_2$ (kHz)	$f_3$ (kHz)	$f_4$ (kHz)
6312 kbit/s	2	0.05	10	0.6	24	120
44 736 kbit/s	14	0.05	10	3.2	900	4500

UI Unit interval

FIGURE 4/G.752

#### Lower limit of maximum tolerable input jitter

#### 1.3.5.2 Multiplex signal output jitter

The jitter at the 44 736 kbit/s multiplexer output should not exceed 0.01 UI rms.

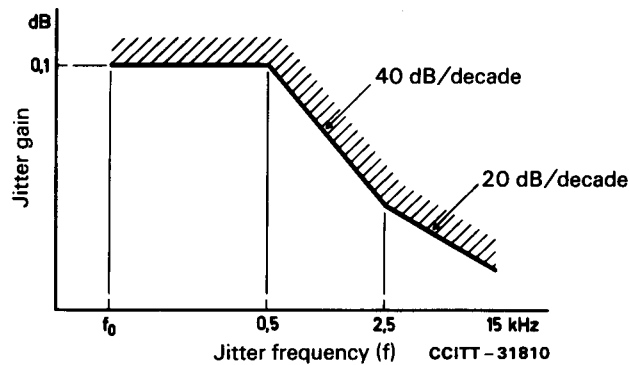
#### 1.3.5.3 Demultiplexer output jitter with no multiplexer or demultiplexer input jitter

With no jitter at the input to the multiplexer and demultiplexer, the jitter at the demultiplexer output should not exceed 1/5 UI peak-to-peak.



#### 1.3.5.4 Demultiplexer jitter transfer characteristic

The gain of the jitter transfer characteristic should not exceed the limits given in Figure 5/G.752.



Note - The frequency  $f_0$  should be as low as possible taking into account the limitations of measuring equipment.

FIGURE 5/G.752

#### Demultiplexer transfer characteristic

#### 1.3.6 Digital interfaces

The digital interfaces at 6312 kbit/s and 44 736 kbit/s should be in accordance with Recommendation G.703.

#### 1.3.7 Timing signal

If it is economically feasible, it may be desirable to be able to derive the multiplexer timing signal from an external source as well as from an internal source.

#### 1.3.8 Service digits

The service digits are reserved for national use.

## 2 Fourth-order multiplex equipment operating at 97 728 kbit/s

#### 2.1 Bit rate

The nominal bit rate should be 97 728 kbit/s. The tolerance on that rate should be  $\pm 10$  parts per million (ppm).

#### 2.2 Frame structure

Table 3/G.752 gives:

- the tributary bit rate and the number of tributaries;
- the number of bits per frame;
- the bit numbering scheme;
- the bit assignment;
- the frame alignment signal.

2.3 *Loss and recovery of frame alignment and consequent action*

The mean frame alignment recovery time should not exceed 1 ms.

The signal to be applied to the tributaries during the out-of-frame alignment time should be all 1s pattern.

2.4 *Multiplexing method*

Cyclic bit interleaving in the tributary numbering order and positive justification is recommended.

The justification control signal should be distributed and the  $C_{jn}$ -bits should be used ( $n = 1, 2, 3$ , see Table 3/G.752).

Positive justification should be indicated by the signal 111, no justification by the signal 000. Majority decision is recommended.

Table 3/G.752 gives the maximum justification rate per tributary and the nominal justification ratio.

TABLE 3/G.752  
97 728 kbit/s multiplexing frame structure

Tributary bit rate (kbit/s)	32 064
Number of tributaries	3
Frame structure	Bit number
Frame alignment signal (110) Bits from tributaries	<i>Set I</i> 1 to 3 4 to 192
Justification control bits $C_{j1}$ (see Note 1) Bits from tributaries	<i>Set II</i> 1 to 3 4 to 192
For justification control bits $C_{j2}$ (see Note 1) Bits from tributaries	<i>Set III</i> 1 to 3 4 to 192
Frame alignment signal (001) Bits from tributaries	<i>Set IV</i> 1 to 3 4 to 192
Justification control bits $C_{j3}$ (see Note 1) Bits from tributaries	<i>Set V</i> 1 to 3 4 to 92
Auxiliary bits $H_n$ ( $n = 1, 2, 3$ ) (see Note 2) Bits from tributaries	<i>Set VI</i> 1 to 3 4 to 192
Frame length Bits per tributary per frame (including justification) Maximum justification rate per tribute Nominal justification ratio	1 152 bits 378 bits 84 833 bits 0.035

Note 1 -  $C_{jn}$  indicates the  $n$ th justification bit of the  $j$ th tributary ( $j = 1, 2, 3$ ).

Note 2 - This signal is  $H_1 H_2 H_3$  pattern where  $H_1$  is the parity bit for the preceding frame, and  $H_2$  is a bit reserved for national use, and  $H_3$  is a bit to transmit the failure information from the receiving end to the transmitting end.

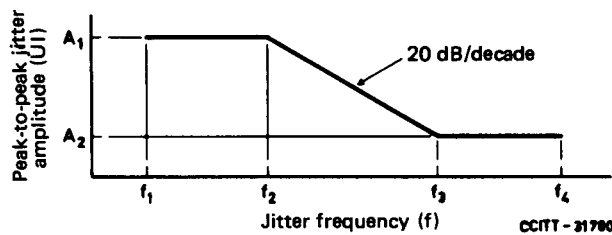
Note 3 - The bit available for justification of tributary  $j$  is the first slot of tributary  $j$  following  $H_n$ .

## 2.5 Jitter

### 2.5.1 Specifications at the input ports

The digital signal presented at the input ports shall be as defined in Recommendation G.703 modified by the transmission characteristic of the interconnecting cable. The input ports shall be able to tolerate a digital signal with these electrical characteristics but modified by sinusoidal jitter up to the limits specified by the amplitude frequency relationship in Figure 6/G.752. The equivalent binary content of the signal, with jitter modulation, applied to the inputs shall be a pseudo-random bit sequence of length  $2^{15} - 1$ .

Note - The signal with jitter modulation applied to the demultiplexer input shall contain the bits necessary for framing and justification in addition to information bits.



Input	$A_1$ (UI)	$A_2$ (UI)	$f_1$ (Hz)	$f_2$ (kHz)	$f_3$ (kHz)	$f_4$ (kHz)
32 064 kbit/s	2	0.2	10	0.8	8	400
97 728 kbit/s	6	0.1	10	5.5	325	1000

UI Unit interval

FIGURE 6/G.752

**Lower limit of maximum tolerable input jitter  
(provisional)**

### 2.5.2 Multiplex signal output jitter

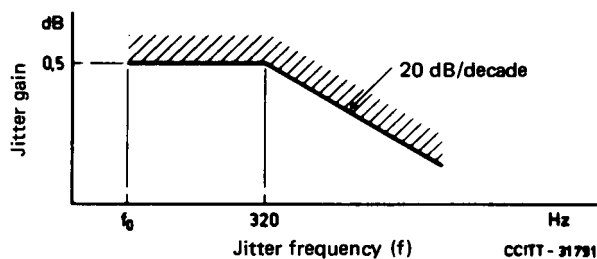
The jitter at the 97 728 kbit/s output of the multiplexer should not exceed 0.01 UI rms.

### 2.5.3 Demultiplexer output jitter with no multiplexer or demultiplexer input jitter

The peak-to-peak jitter at a tributary output of the demultiplexer with no jitter at the inputs should not exceed 0.25 UI.

#### 2.5.4 Demultiplexer jitter transfer characteristic

A 32 064 kbit/s signal, modulated by sinusoidal jitter, should be subject to a demultiplexer jitter transfer characteristic within the gain/frequency limits given in Figure 7/G.752.



Note - The frequency  $f_0$ , should be as low as possible taking into account the limitations of measuring equipment.

FIGURE 7/G.752

#### Demultiplexer transfer characteristic

#### 2.6 Digital interface

The digital interfaces at 32 064 kbit/s and 97 728 kbit/s should be in accordance with Recommendation G.703.

#### 2.7 Service digits

The service digits are reserved for national use.

#### Reference

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